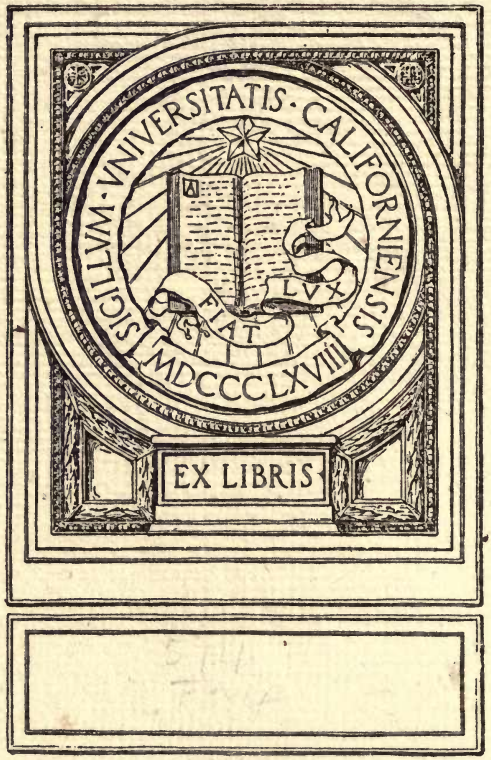
GALVANIZING AND TINNING

Hot Galvanizing
Electro-Galvanizing
Sherardizing
Schoop Spray Process
Tinning & Re-Tinning

W. T. Flanders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GALVANIZING
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TINNING

A Practical Treatise on the Coating of Metal with Zinc and Tin by the Hot Dipping, Electro-Galvanizing, Sherardizing and Metal Spraying Processes, with Information on Design, Installation and Equipment of Plants.

By W. T. FLANDERS
MALLEABLE IRON FITTINGS CO.

With the Assistance of the following Specialists

JOHN CALDER,	Metal Coatings Co. of America
R. D. FOSTER,	Hanson & Van Winkle Co.
C. J. KIRK,	U. S. Sherardizing Co.
A. F. SCHOEN,	New Haven Sherardizing Co.
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PREFACE

THE original work "Galvanizing and Tinning" was prepared to meet the demand for reliable information on the methods of protecting iron and steel from corrosion which the editors of the *Metal Worker* and *The Iron Age* were continually receiving. Mr. Flanders, who had specialized on the hot dipping processes of coating with zinc and tin for many years, was induced to describe the proper design and equipment of plants and the methods he had found most satisfactory.

Since it was published, many improvements have been made in the hot galvanizing and tinning processes. Several new methods of utilizing zinc and tin for protection against corrosion have also been devised and perfected. Mr. Flanders did not feel qualified to treat these new processes, and, as a majority of them are covered by patents, it was difficult to obtain practical information regarding their application, as well as the design and installation of the apparatus.

Several of the experts who had specialized on the new processes refused to contribute because they deemed their methods "trade secrets," while others supplied splendid advertising matter for their special process, but little practical data.

However, Mr. E. P. von Gogh, Book Manager of *The Iron Age,* whose years of experience and careful study of the subject qualified him to know the kind of information the man actually handling the work wanted, was determined to obtain it, and finally succeeded in enlisting the co-operation of men who were broad-minded enough to put the needs of the trade above their personal desire for gain. The names of these leaders in their respective fields, who have given so freely from their wide experience and study of their specialties, are given on the Title Page of the book.

Every effort has been made to keep the book free from advertising statements. A special Publicity Section is given at the end of the volume, where the manufacturers and dealers in galvanizing and tinning apparatus and supplies have set forth the relative advantages of their products. This "trade directory" ought to be of exceptional value to those who contemplate the installation of

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a plant or the purchase of supplies, as well as to those who wish to dispose of their waste. In writing advertisers, please mention that you saw the adv. in "Galvanizing and Tinning."

The treatment of hot galvanizing and tinning is as comprehensive and reliable as Mr. Flanders' practical experience could make it. This covers a period of over thirty-five years as mechanic, builder and manager of plants. He was ably assisted in this work by Mr. H. A. Smith, who contributed a large amount of data that is new.

In revising the chapter on re-tinning, Mr. Flanders received much valuable assistance from Mr. W. C. Holland, a former shopmate, and from Mr. J. B. Smith, mechanical engineer, and Mr. W. E. Mumford, metallurgist.

Many interesting and valuable articles by other experts, bearing on protective coating of zinc and tin, which have appeared in various trade papers, have been included and proper credit given in the text.

The aim of all who have assisted in the preparation of this work has been to make it of the greatest practical value to the men actually engaged in the plant, as well as to those who are contemplating the installation of plants. If the readers of the book fail to find the information they desire, the publishers will be pleased to have them submit the problems for the consideration of the experts who collaborated in making it so nearly complete.

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FIG. 1. HOT GALVANIZING AND TINNING PLANT OF MALLEABLE IRON FITTINGS CO.

Galvanizing and Tinning

CHAPTER I

Corrosion and Its Prevention

IRON and steel will invariably rust or corrode if exposed to the atmosphere without protection, and Mr. Alfred Sang, in *The Iron Age,* explains the reasons for this fact in an excellent manner, as follows:

"One of the most persistent problems which confront the worker in iron and steel is the prevention of corrosion. We cannot rid ourselves of the agents which effect the corrosion of iron without at the same time ridding ourselves of the agents which are essential to life itself.

"Air is indispensable both to human respiration and for the formation of rust and other oxides, for which it supplies the oxygen; moisture is necessary for the formation of clouds, which make the earth fertile, and it also supplies the medium in which rusting takes place and hydrates the oxide; carbonic dioxide is an animal by-product and a raw material for the vegetable world, and the exchange of carbonic dioxide and oxygen, which is continually taking place between the animal and the vegetable kingdom, is of vital importance. Then, on the other hand, rust is not readily formed, if at all, unless there be an acid present, and the acid which is most universally distributed is carbonic acid, or hydrated carbonic dioxide.

"There is, as you see, a close relationship between the processes of living and rusting, but, while human beings make up for the rusting or decaying of their tissues by nutrition, it has not yet been discovered how to feed or regenerate iron, and until such a discovery is made we are compelled to take our cue from the ancient Egyptians and resort to embalming.

"There are two general ways of embalming iron to prevent its decomposition, which might be called, respectively, the metallic and non-metallic methods. In the non-metallic method the ar-

ticles are coated with an organic substance, usually oil, or varnish, the efficiency of which depends on its being more or less airtight; when coloring matter is added to the oil it becomes a paint, but I understand from authorities on the subject that a varnish free from pigments is preferable to anything else. The metallic method consists of coating the iron with some other metal, and it is this method which I have come to discuss with you.

"Iron rusts less easily than does steel; this is perhaps due to steel being a very composite material. In the iron, which forms the bulk of its composition, are dissolved or immersed a great variety of other substances; some of these are simple, such as graphite, silicon and manganese, and others are compound, such as carbides, sulfides, phosphides and silicides. The carbon compounds are very numerous and diversified, being due to different heat treatments; the best known are cementite, pearlite and martensite. Just as variety is to some people the spice of living, so is heterogeneous composition the spice of rusting, in the present instance at any rate. Nor is this by any means a solitary instance; it is a well-known fact that chemically pure zinc is dissolved very slowly by certain acids, whereas the commercial product, especially if it be high in iron, is rapidly dissolved."

Great trouble and expense annually falls upon manufacturers, metal workers and property owners through the rusting or corroding of iron and steel. An illustration of this is shown by the following, which recently appeared in *The Iron Age:*

"The receivers of Milliken Brothers, Incorporated, 11 Broadway, New York, have lately made some extensive experiments in connection with protecting from oxidation steel grillage beams used in building construction. More or less water is present in nearly every building where grillage beams are used. Therefore, unless the beams are absolutely protected, there will be oxidation. As such beams are not usually exposed to view and cannot be examined, if oxidation takes place after the building is up and the oxidation becomes serious, the security of the building is threatened.

"Finding that coating the beams with paint, asphalt or tar cannot be absolutely relied on for a great length of time, Milliken Brothers have experimented with galvanizing by the hot process, after all the shop work has been done on the steel. It has been shown that concrete will adhere to galvanized steel

beams as firmly as to unpainted beams, and much better than to painted beams. Architects and engineers who have had occasion to examine galvanized Ashlar anchors and galvanized pipes used in connection with concrete have found that concrete will attach itself as readily to galvanized material as ungalvanized material. The advantage of galvanizing is that it gives the steel beam a complete zinc coating which will resist the action of the water and therefore protect the steel. The expense connected with the galvanizing is considered small in comparison with the resulting benefits."

Zinc Coating the Best Rust Preventive

It is my purpose in this volume to deal with the subject of coating iron and steel products with zinc, or, as generally termed, galvanizing them (to prevent rusting), which has become a large and important industry in which much capital is invested and many men are employed. Zinc is without doubt the best protective coating for iron and steel, and the reasons are clearly stated in *The Brass World,* which says:

"It is difficult for many persons to understand why zinc is the best rust preventive for iron or steel, and they believe it is on account of its cheapness that it is so extensively used. They have an idea that lead, being a cheaper metal, would answer far better, and as it is more non-corrosive than zinc, would protect the iron better. This is not a fact, however, as will subsequently be explained.

"The very fact that zinc is a corrosive metal does not affect its properties when applied as a coating to iron or steel. Indeed, if it did not corrode, it would not be of value for such a purpose. When iron or steel, which has been coated with zinc, is exposed to the atmosphere, a galvanic action is set up, although, of course, extremely slight. Any two dissimilar metals form a galvanic couple, but as zinc is the most electropositive metal, the galvanic action between the zinc and iron is as great as could be obtained when iron is used for one of the metals composing the couple.

"The result is, therefore, that with the slight galvanic action set up on galvanized iron or steel, when exposed to the atmosphere, a corrosion takes place. Did it not follow, then there would be no protection. In this case, the zinc, being the electropositive metal, suffers corrosion at the expense of the electro-negative metal iron. The effect is that the corrosion goes on with the zinc exclusively

and iron is not corroded at all, provided any zinc is left on the iron or steel. This condition takes place whether a light or heavy coating of zinc is present. The only advantage of a heavy zinc coating is that it will last longer, but under ordinary atmospheric conditions, where a slight amount of moisture is the only exciting liquid, the galvanic action is very small and the zinc coating, be it ever so light, lasts a long time. In the case of sea-water or air saturated with salt moisture, the corrosion, of course, is much more rapid and a heavier zinc coating is required to resist it for a length of time.

"The reason for the protection of iron or steel by a zinc coating is, therefore, on account of the fact that the zinc corrodes at the expense of the iron or steel by the galvanic action set up. Zinc, however, when exposed to the air, does not corrode rapidly or deeply and, in fact, very lightly. This property is of great value, as the zinc coating does not corrode rapidly, even with the galvanic action set up, so that it lasts for a far greater length of time than would naturally be expected. The very fact, however, that the zinc corrodes at the expense of the iron is all that is necessary to protect the iron or steel, even though it be extremely slight.

"Other metals like lead or tin, on account of their not being electropositive to iron, do not act like zinc. They act simply as a covering like a paint or varnish, and if portions of the iron happen to be exposed, even such as a pinhole, the iron begins to corrode. With a zinc coating, however, this will not take place."

Therefore there are well founded reasons for the growth and development of the galvanizing industry, since zinc is the best protective coating for iron and steel and is comparatively low in price.

The oldest galvanizing process and the one most generally used is the hot or dipping process, although the "cold" or Electro process is used to considerable extent and it has unquestionably gained ground since its invention, about twenty years ago. Sherardizing has come into use since the introduction of the Electro process. While its inventor does not use the term "galvanizing" in connection with the Sherardizing process, it is, in fact, as truly a galvanizing process as is the hot dipping or Electro process. The protective coating in the Sherardizing process is metallic zinc deposited from zinc dust or zinc oxide, while in the hot and Electro processes the zinc is used in the form of slabs or cast anodes.

As the hot or dipping process is the oldest, we will give it our first attention, and writer will describe to the best of his ability methods employed in the different branches of the business, giving principal attention to miscellaneous work, such as gray or malleable iron castings, wrought iron and steel forgings, coal hods, and other articles made from sheet iron, devoting for obvious reasons short paragraphs to the galvanizing of sheets, pipe, wire, wire cloth and poultry netting. The galvanizing of these materials is simply one process in their manufacture; and most of the concerns producing them either use methods of their own or patented devices, which it would be unfair on one hand, and useless on the other, to describe. Job shops for the handling of miscellaneous galvanizing are found in nearly all large cities in this country, and many manufacturers of specialties operate their own galvanizing plants.

It may not be out of place to say that it has been, and still is, the practice of some engaged in this business to make as much of a mystery of the operations as possible. Mystery and secret formulæ were looked upon (not so many years ago either) as the key to monopolizing many so-called metallurgical processes; but those times have passed, and the reading public will have little trouble in following out any present methods if it will note the publications and lucidly written books bearing on the subjects in question. One fallacy generally credited is that galvanizing kettles must never be allowed to cool off. While it is true that it is not advisable to allow a kettle holding several tons of zinc to cool off at frequent intervals, and it is not in the interest of economy for one having a small amount of galvanizing to attempt to do it himself, there is no reason why a kettle containing a few hundred pounds of metal cannot be operated fairly successfully, and possibly to good advantage, if one is not conveniently located for sending the work to a jobbing galvanizer. We wish to impress the reader with the fact that we are not advocating the installation of a galvanizing plant as a matter of economy unless one has sufficient work to keep it in constant operation and employ skilled help. Unskilled workmen cannot produce best results, and the materials he must use are expensive. The operation of a very small plant will be found a costly experiment at the best, and should never be attempted unless actually necessary.

CHAPTER II

Hot Galvanizing Plant and Equipment

TO THOSE contemplating the installation of a galvanizing plant the first consideration should be to isolate it as much as possible from the main factory, as the fumes arising from the chemicals used in the business are not only destructive to tools and machinery, but to many kinds of finished goods. It is very difficult to dispose of these fumes in such a way that they will not prove an annoyance as well as a menace to machinery, tools and stock.

The Galvanizing Room

In fitting up a room or building in which to locate the plant provision should be made to obtain the best possible ventilation. The building should be high posted, with a good ventilator in the

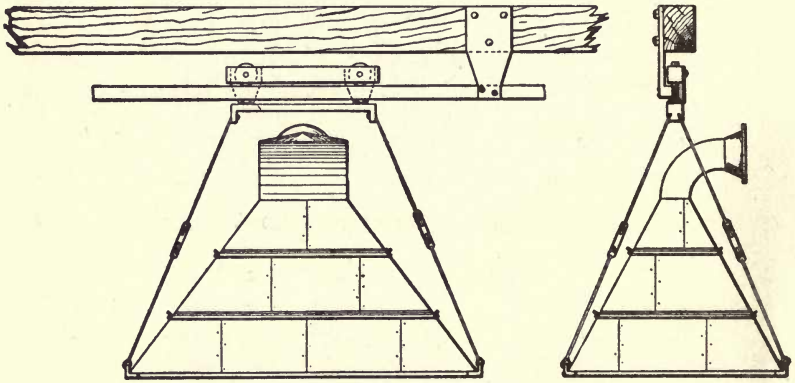

FIG 2—FRONT AND SIDE ELEVATION OF A MOVABLE HOOD

roof, and better working conditions are obtained by covering the kettles and acid tanks with hoods connected to an exhaust fan of suitable size and speed. If an exhaust fan is used, most of the fumes arising from the kettles and acid tanks can be discharged into a stack or chimney of suitable height, and thus disposed of making conditions fairly comfortable.

Where hoods are used over the kettles and tanks they should come as low as possible and not interfere with the workmen. They should be large enough to project well beyond the kettles or tanks so as to catch everything possible in the way of steam and smoke that naturally rises when the plant is in operation. When the work consists of castings and other small articles, there is no objection to having the hoods come to within 6 feet 6 inches of the floor. Where hoods are used on large kettles they should be suspended from a carriage or trolley on an overhead track which will permit of their being easily moved out of place when it is desirable to do so. We illustrate our method of putting up a movable hood by Fig. 2, although it is entirely possible that something much better might be devised.

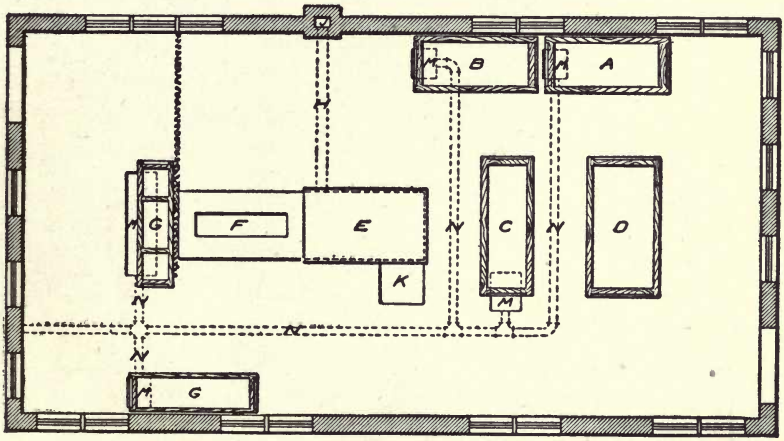

FIG. 3—SHOP ARRANGEMENT WITH TILE DRAINS FOR ACID TANKS

Considerable water is used in the hot process of galvanizing when miscellaneous work is done, and provision should be made to secure proper drainage. A good plan is to put catch basins under the various acid and water tanks, connected by tile pipe to sewer, as shown in floor plan, Fig. 3. The floor can be cement or brick.

If the work to be handled is gray iron it is not absolutely necessary to use steam, but if it is of a nature that requires the removal of scale, or if malleable castings are to be galvanized in quantities, steam should be brought into the room.

A floor space 25 feet by 48 feet will accommodate an outfit such as we illustrate in Fig. 3. Much less floor space can be made to accommodate a very small plant that is designed to operate only at irregular intervals.

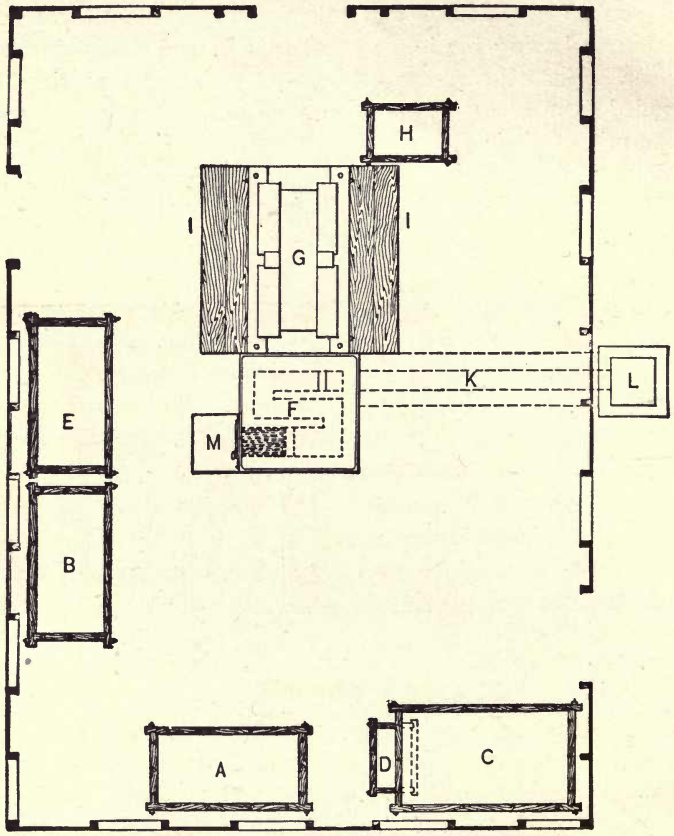

FIG. 4—FLOOR PLAN OF GALVANIZING ROOM WITH UNDERGROUND FLUE

Fig. 3 is the ground plan of a galvanizing plant, in which A is a tank for containing a solution of sulphuric acid and water for removing scale and rust; B is a water tank for storing work that has been cleaned; C is a tank for muriatic acid; D is a tank for hydrofluoric acid; E is the plate for drying the work before immersing it in the molten zinc; F is the kettle containing the molten zinc; G G are tanks, one of which is divided, and contain

the water used for cooling the work after it has been removed from the galvanizing bath; H is an underground flue connecting the drying plate E with the chimney or stack J; K is a pit giving access to the fire and ash pit under the drying plate E; M M are catch basins, located under the several acid and water tanks, with tile pipe connections N to sewer.

Another plan of a galvanizing plant is shown by Fig. 4.

This plant, which occupies a floor of 25′ x 50′, was designed for use where the old-fashioned method of pickling sandy castings with sulphuric acid was to be employed. A small plant of this kind could be put in a much smaller floor space. In floor plan Fig. 4, A is a tank for containing a solution of sulphuric acid and water for removing scale and rust. B is a water tank for storing work that has been cleaned. C is a platform where castings are placed to free them from sand with the use of sulphuric acid. D is a tank used to contain the solution for removing the sand from the castings after they have been placed on the platform. E is a tank for containing muriatic acid. F is the plate for drying the work before immersing it in the molten metal. G is the kettle containing the metal, and H is the tank used for cooling the work after it is coated with the zinc. I I indicate the loose planks covering the ash pits, shown in Fig. 11 as P P. K is an underground flue connecting the drying plate F with the chimney or stack L; and M is a pit to give access to the ash pit under the drying plate F.

The Equipment

The equipment of a galvanizing plant for miscellaneous work consists of a kettle of suitable size, which should be built of the very best material obtainable; a drying "arch," "plate" or "oven" for drying the castings prior to immersing them in the molten zinc; wooden tanks for containing water and the different acid solutions; and miscellaneous tools best adapted to the work in hand, such as tongs, hooks and baskets of perforated sheet iron or wire cloth. Considerable ingenuity can be exercised in devising implements for handling the various kinds of work. We shall refer to this matter of tools later under a special head.

The material used in the construction of galvanizing kettles and tools which come in contact with the molten spelter is a matter of great importance. In this connection, the statement of the super-

intendent of one of the largest sheet galvanizing plants in the country is interesting, and we give it herewith.

The endeavor to find the most suitable material for manufacturing those parts of the machinery which are immersed in spelter, as well as the best container for the molten spelter, has occupied the attention of galvanizers for all time. The only substances which are not dissolved are vitreous, and consequently, impractical. All of the common metals are soluble in molten zinc, and all of them are miscible in all porportions, with the exception of lead and iron. For this reason, and because of the many other desirable properties which iron possesses, it is universally used at the present time.

The old galvanizers made their machinery of wrought iron; but with the introduction of Bessemer and open hearth steel have quite generally adopted this material, because it possesses certain very distinct advantages over wrought iron. It does, however, go into solution much more rapidly than the old wrought iron did; so that for the last ten years the search has been for a material which will work as well as steel does, and resist the solvent action as well as the iron.

The laws of physics teach us that an impure substance will go into solution more rapidly than a pure one, and we do not find exceptions when dissolving iron in zinc. The purer the iron the more slowly it goes into solution. This is the reason that the old-fashioned puddled iron lasted so much longer than the modern steel. Now that ingot iron is being commercially produced, it has been very easy to demonstrate this fact in a scientific manner.

In a recent investigation the following facts were disclosed: Sixteen gauge samples of various analysis were suspended in molten spelter for twelve days with the following results:

	Armco Iron	Steel	Steel
Sulphur	.032	.036	.022
Phosphorus	.008	.067	.006
Carbon	.010	.045	.010
Manganese	.017	.372	.145
Silicon	trace	trace	trace
Copper	.048	trace	.192
Loss in 12 days	11.2%	40.9%	27.00%

Having satisfactorily demonstrated that there was a very marked difference between pure iron and steel (impure iron), another set

of experiments was conducted to bring out the difference in the effect between slight variations in very pure iron. Samples of the following analysis were used, and were suspended for four hundred fifty hours (three 150 hour periods).

	1	2	3	4	5
Silicon	trace	trace	trace	trace	trace
Sulphur	.022	.025	.025	.026	.027
Phosphorus	.003	.004	.003	.003	.005
Carbon	.015	.04	.015	.01	.10
Manganese	.02	.005	.04	.01	.065
Copper	.045	.035	.11	.11	
Oxygen	.015	.017	.025	.041	.03
Total Impurity	.120	.126	.218	.200	.227
Iron by difference	99.88	99.874	99.782	99.80	99.773
Loss in 450 hours	34.4%	38.5%	42.0%	55.7%	(41.5% loss in 300 hours.)
Average weight of coating in 150 hours	370	314	272	248	212

It will be noticed that the rate of solution increases directly in proportion to the amount of impurity. These specimens were all weighed very carefully, were totally immersed in spelter, not coming in contact with the salammoniac flux at any time; the coating being stripped off with sodium hydroxide, which dissolves the spelter but does not attack the iron. From these results it is evident that while dealing with commercially pure iron it is essential to secure the very purest. A material containing 99.84% iron being much better than one containing only 99.75% iron. You will note also that the rate of solution increases with the amount of oxygen; showing the additional necessity of securing a thoroughly degassified and deoxidized material.

Another interesting fact to be noticed in the table given above is that the weight of coating taken on varies inversely as the rate of solution; that is, the more rapidly the material dissolves, the lighter coating it takes on.

These facts as worked out in the laboratory are very interesting, but needed verification in actual practice before they could be of any real importance to the galvanizer. For this reason, all parts of the galvanizing machine under the spelter, in one manufacturer's plant, were manufactured of Armco Iron. He finds that cast Armco Iron lasts just about as long as rolled or forged 10 carbon steel; whereas Armco Iron, properly worked and heat

treated, will last from three to seven times as long as mild steel will. Flux boxes, for example, lasting from eight to ten months.

These statements are borne out and given additional weight by a comparison of galvanized Armco Iron sheets with galvanized mild open hearth steel sheets. The iron content of a clean spelter bath is approximately .02%. Any iron in excess of this forming dross, and settling to the bottom. The coating on Armco Iron sheets contains about 3% iron, while the coating on steel sheets contains about 4%; showing very definitely that even in the short time that the sheets are in the spelter bath, steel goes into solution much more rapidly.

It is a source of great satisfaction to know that a material is being commercially produced, which lasts even longer in the spelter than the old-fashioned wrought iron, and at the same time possesses all the excellent working qualities of steel.

The Selection of a Kettle

In deciding what size kettle to install one must be guided by the nature and quantity of work to be done. If small articles are to be handled, and the quantity is such as to require the plant to be operated only at intervals, a kettle 3 feet long, 15 or 18 inches wide and 20 inches deep will answer every purpose, but it is extremely difficult to keep an even temperature of the metal in a kettle of this size. The only excuse for using such a small kettle is for doing an extremely limited amount of work as a matter of convenience, with cost as a secondary consideration.

Bricking in a Galvanizing Kettle

There are several methods of heating galvanizing kettles. Some are heated with soft coal, some with fuel oil and some with natural gas. The fuel most commonly used, however, is coke. For this reason we shall show, by illustrations, three methods of bricking in coke-fired kettles. We do not attempt to describe any particular method of oil or natural gas heating, as concerns using either fuel usually have their own methods of application.

Figs. 5, 6 and 7 show methods of setting a small kettle not deep enough to require ash pits at the sides and not designed to be operated continually. The grates F F are bars of iron that may be withdrawn when it is desired to let the fires out, and replaced when required for use. Fig. 5 is a top plan of the brick work and

kettle. Fig. 6 is a vertical cross section of Fig. 5 at A A, and Fig. 7 is a horizontal section of Fig. 6 at B B.

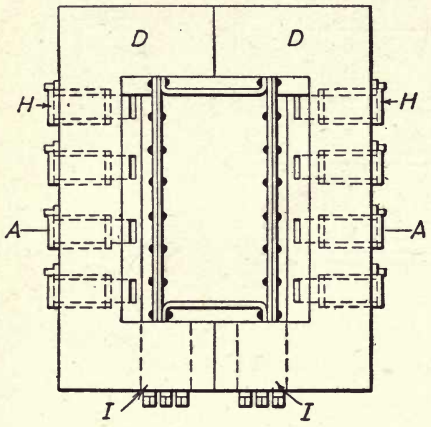

FIG. 5—PLAN OF KETTLE

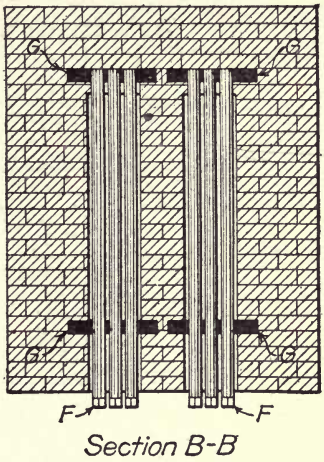

FIG. 7—ARRANGEMENT AT GRATE LINE

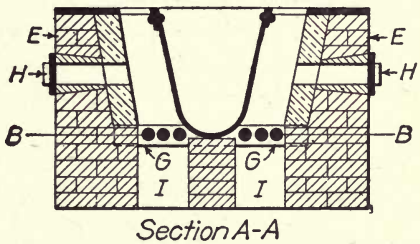

FIG. 6—VERTICAL CROSS SECTION OF FURNACE AND KETTLE

Fig. 8 shows the casting details for setting kettle as shown in Figs. 5, 6 and 7. D is a plate to cover top of brick work surrounding the kettle, and its position is designated in Fig. 5 as D D. E is a casting used on outside of brick work on both sides of kettle and in connection with bolts passing through their ends serve to bind the brick work together. Their position is designated in Fig. 6 as E E. F is a grate bar, the position of which is shown in Fig. 7 at F F, and G G are the castings for supporting each end of the grate bars F. Their position is designated as G G in Figs. 6 and 7. The castings for the upper and lower draft hole casings with doors, designated as H and I in Figs. 5 and 6, can be made the same as castings K, L, M and N in Fig. 13.

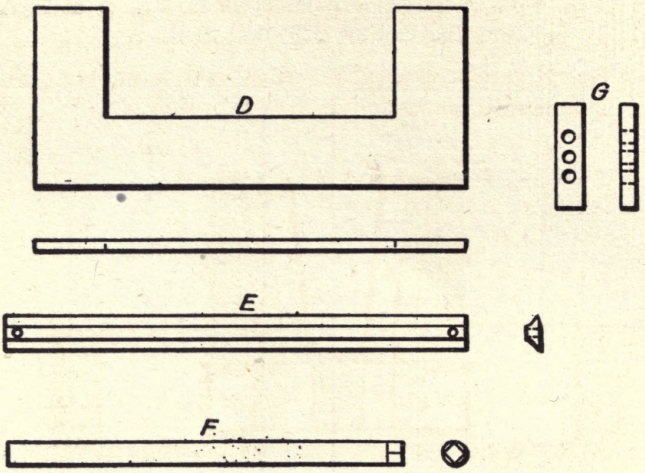

FIG. 8—CASTING DETAILS FOR SETTING KETTLE

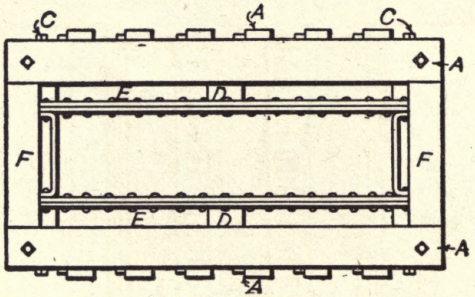

FIG. 9—TOP PLAN OF BRICKWORK FOR LARGER KETTLE

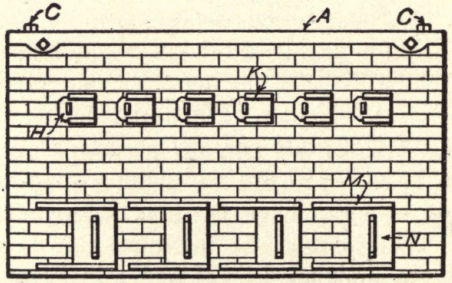

FIG. 10—SIDE ELEVATION OF THE SAME KETTLE

Figs. 9, 10, 11 and 12 show manner of setting larger kettles where grates are used; Fig. 9 being a top plan of the brick work; Fig. 10 a side elevation; Fig. 11 a vertical section at A A; Fig. 9 and Fig. 12 a horizontal section at the grate line.

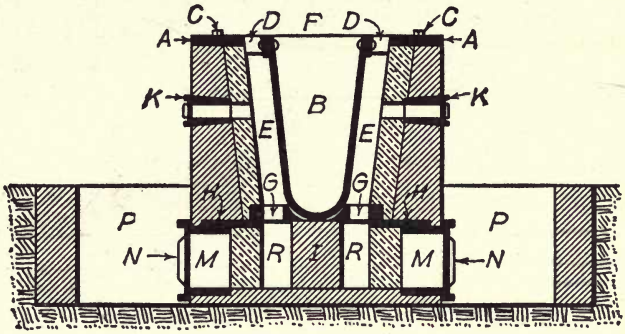

FIG. 11—VERTICAL CROSS SECTION OF KETTLE AND FURNACE

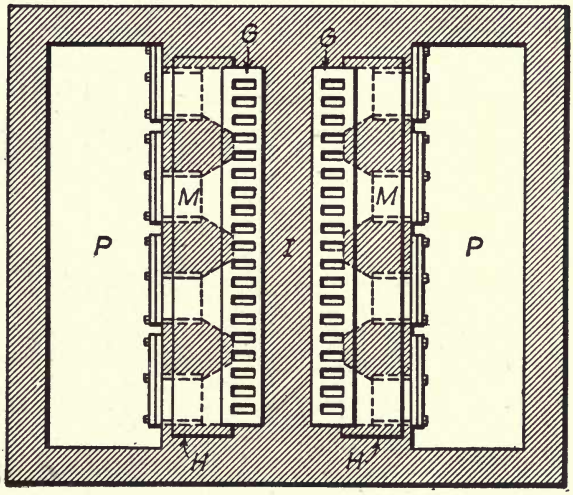

FIG. 12—HORIZONTAL SECTION AT THE GRATE LINE

Fig. 13 gives details of all castings necessary for setting all grate-fired kettles, as shown in Figs. 9, 10, 11 and 12. A, Fig. 13, is a coping plate, the position of which is shown in Figs. 9, 10 and 11 as A A. These plates, when held in place by the bolts C, serve to prevent the sides of the kettle from springing outward when the iron blocks D, Fig. 13, are in their place, as shown in

Figs. 9 and 11. Coping plates for kettles 4 to 6 ft. long should be 2½ inches thick and 10 inches wide. The fire spaces E E in Figs. 9 and 11 should not be more than 7 inches wide, and the same length as the inside of the kettle. F in Fig. 13 is an iron plate 1 inch thick, and the position of these plates on the brick work is shown as F F in Figs. 9 and 11. G in Fig. 13 is a section of grate, the position of which is designated G G in Figs. 11 and 12. The openings of these grates should be about 1 inch wide, and the

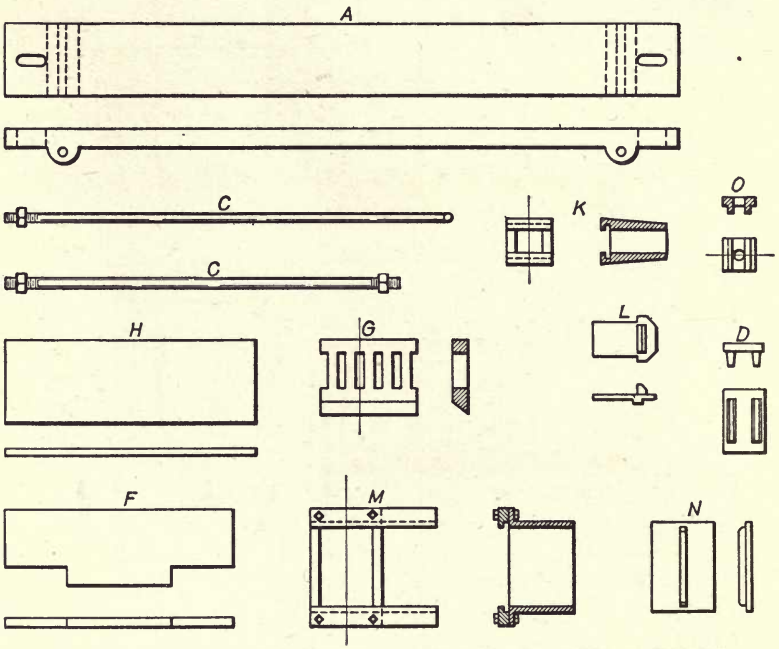

FIG. 13—DETAILS OF CASTINGS FOR SETTING GRATE-FIRED KETTLE

grates should be wide enough to span the fire spaces E E in Figs. 9 and 11 and rest on plates H H and the pier I on which the kettle B rests, as shown in Fig. 11. Plates like H in Fig. 13 are used to rest the outer edge of the grates G G on, as shown in Figs. 11 and 12, and also to help support the brick walls on each side of the kettle. Plates such as H in Fig. 13 may also be used to cover the top of fire boxes E E in Figs. 9 and 11, and should be about ¾ inch thick and 12 inches wide; their length to be determined by the length of the kettle. K in Fig. 13 is a cast iron casing for the

upper draft holes, indicated as K K in Figs. 10 and 11. These casings should be about 10 inches long with openings about 4 by 4 inches. They should also be arranged to close with sliding doors L, as shown at L, Fig. 10. M in Fig. 13 shows a cast iron casing for the lower set of draft holes in which the openings should be about 8 by 12 inches. Their position in the brick work is designated M in Figs. 10, 11 and 12. N in Fig. 13 is a sliding door for the draft hole casings M, and they are designated N in Figs. 10 and 11. O in Fig. 13 is a cast iron foundation washer which is built in the brick work on the bottom ends of the vertical bolts C. The ash pits P P, Fig. 11, should be about 2 feet wide and covered with loose floor planks so that easy access may be had to the ash pits for the purpose of opening or closing the lower

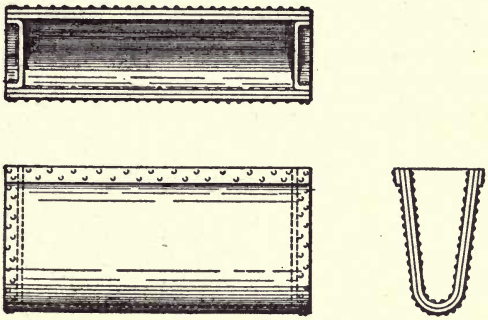

FIG. 14—PLAN AND ELEVATIONS OF KETTLE

drafts, and also for removing the ashes from the spaces R R under the grates G G. Fig. 12 shows the grates G G in position, and also the manner of laying the bricks between the draft casings M M. I indicates the pier on which the kettle rests. It will be seen that the brick work between the lower draft casings M M is built in a way which will allow all possible access to the grates G G from the ash pits P P. The walls along each side of the kettle should have a lining of fire brick extending from the grates upward to the coping plates A A, as shown in Fig. 11.

Fig. 14 shows a kettle in which the body is formed of one piece, with rivets placed where the fire will not affect them. While a kettle for general use built after this illustration is our preference for many reasons, it does not follow that the work could not be done in a kettle of some other shape.

Figs. 15, 16 and 17 show the setting of kettles fired without grates and with only one set of draft holes. Fig. 15 is a sectional

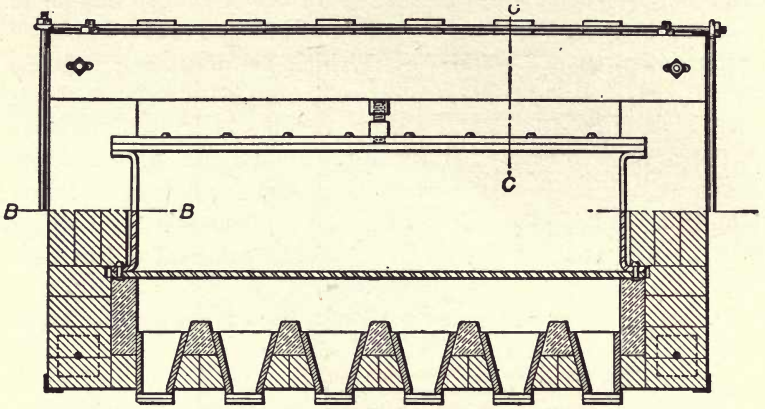

FIG. 15—SECTION OF BRICKWORK AND KETTLE AT A A, FIG. 17

plan of the brick work and kettle through 17 at A A. Fig. 16 is a sectional side elevation through Fig. 15 at B B. Fig. 17 is a sectional end elevation through Fig. 15 at C C.

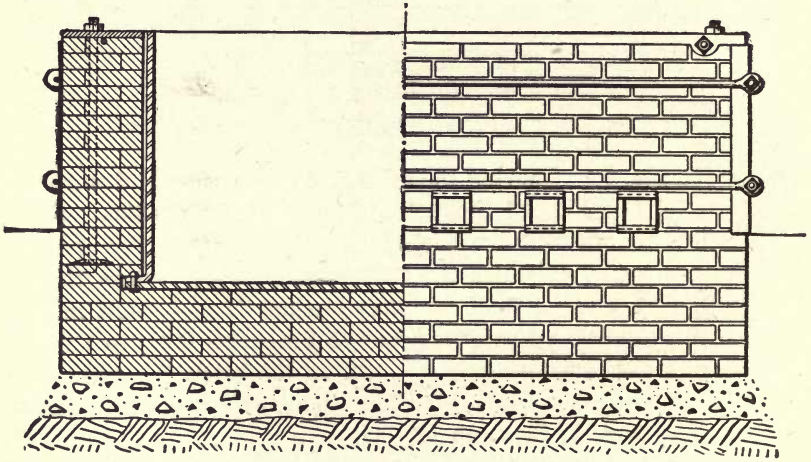

FIG. 16—SIDE ELEVATION AT B B, FIG. 15

Figs. 18 to 23 show construction of a simple and effective arrangement for drying castings previous to dipping them in the molten zinc. Fig. 18 is a side elevation of a "drier" showing

furnace front with fire and ash pit doors. Fig. 19 is a longitudinal section of Fig. 22 at C C. Fig. 20 is a lateral section of Fig. 22

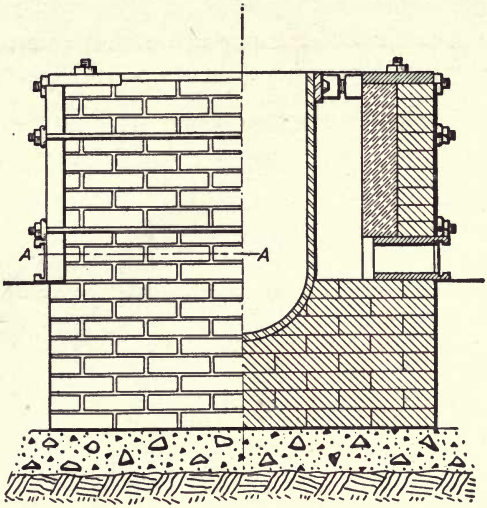

FIG. 17—SECTION AT C C, FIG. 15

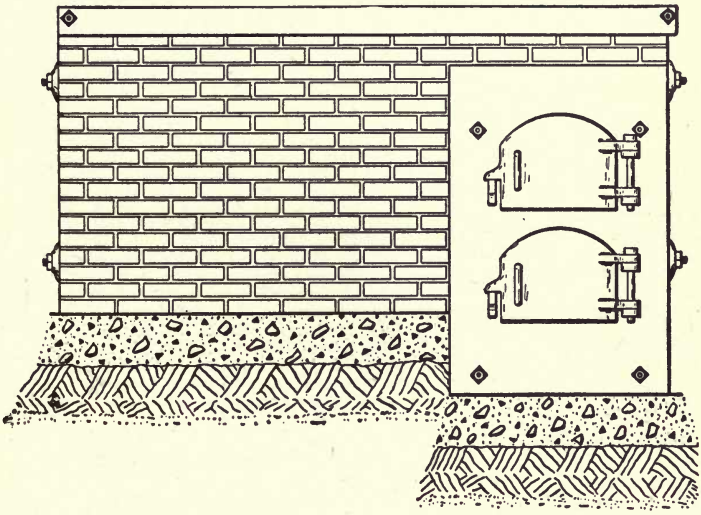

FIG. 18—GENERAL VIEW OF FURNACE FOR DRYING CASTINGS

at A A. Fig. 21 is a lateral section of Fig. 22 through B B, showing ash pits and grates. Fig. 22 is a longitudinal section of

Fig. 21 through D D, and shows arrangements of flues. Fig. 23 is a longitudinal section of Fig. 21 through E E, and shows grate and fire box with fire brick lining.

We give the method of setting kettles with and without grates for the reason that there is a diversity of opinion as to which is

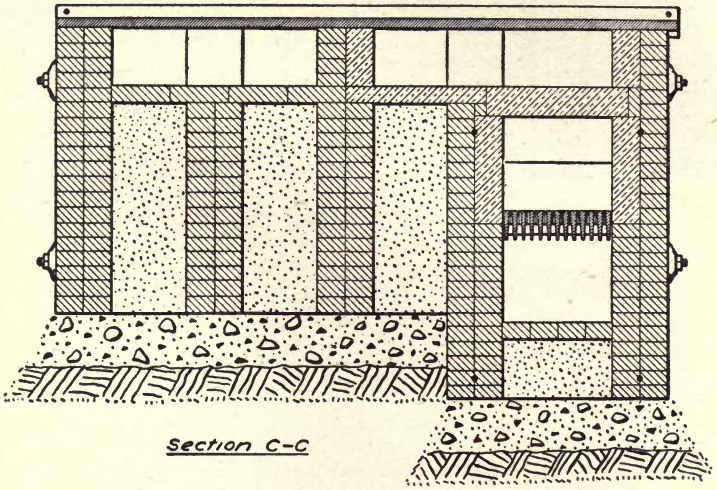

FIG. 19—LONGITUDINAL SECTION AT C C, FIG. 22

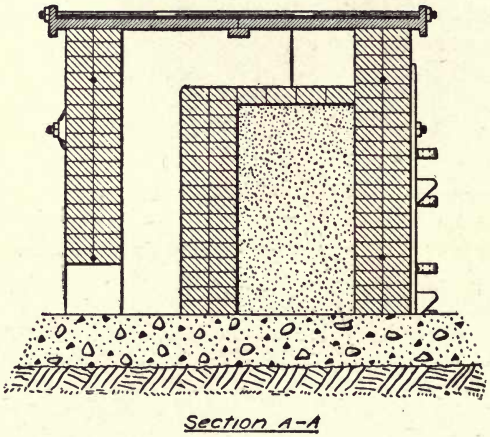

FIG. 20—CROSS SECTION AT A A, FIG. 22, SHOWING FLUES

the better method. Without discussing this matter pro or con, the author will simply say that he prefers a kettle fired without grates. Some claim that a grate fired kettle lasts much longer than one

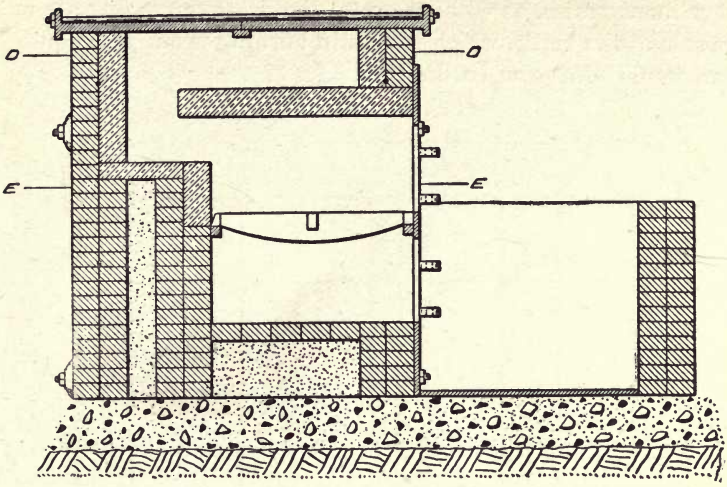

FIG. 21—VERTICAL SECTION THROUGH B B, FIG. 22, SHOWING FURNACE AND FLUES

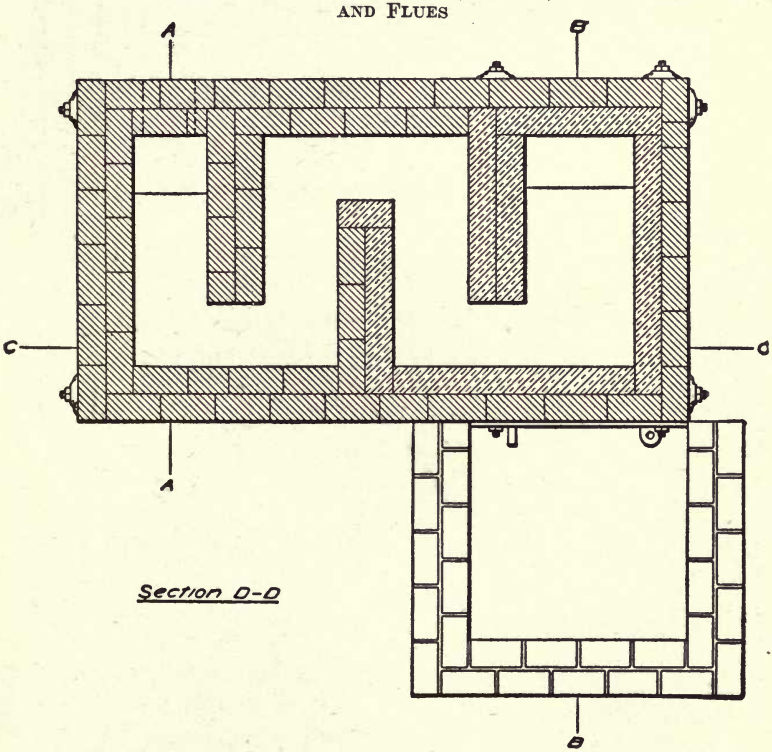

FIG. 22—PLAN OF DRIER, SHOWING TOP FLUES AT D D, FIG. 21

set without grates, as without grates the draft comes directly onto the side of the kettle, which results in burning it out much quicker than would otherwise be the case.

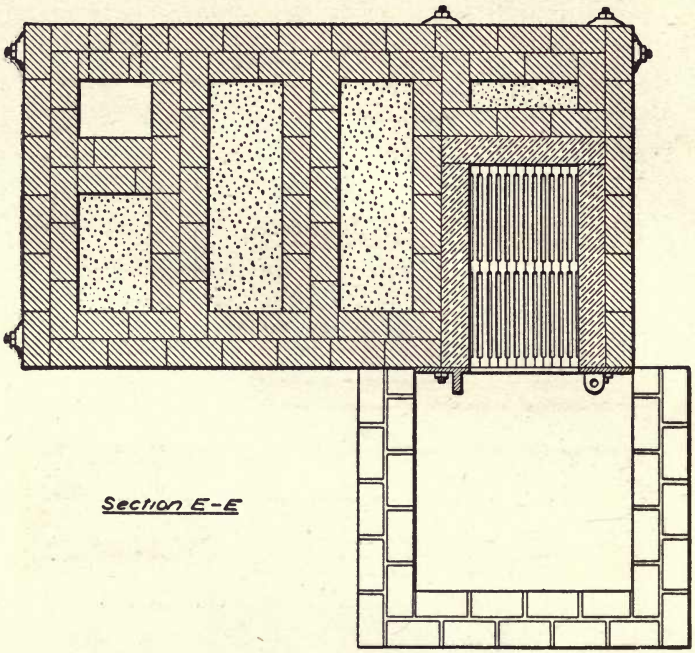

FIG. 23—PLAN SHOWING GRATE AND FIRE BOX AT E E, FIG. 21

Tanks for Acid Solutions and Water

In our opinion, the best lumber for acid tanks is cypress, although some prefer the different varieties of pine. Most galvanizers use wooden tanks for containing the cooling and rinsing waters. Water tanks made of boiler iron will give very good service, in fact they are more economical than wooden water tanks. Wooden tanks for holding the various acid solutions should invariably be put together with copper bolts, nuts and washers, and it is a good plan to line the inside of such tanks with rough boards that can be replaced when worn out. These linings protect the inside of the tanks and will increase their life very materially. It will be found a good plan to coat the inside of wooden tanks intended for cold acid with asphaltum. The asphaltum should be heated as

hot as possible without danger of its catching fire and put on thickly with an old broom. When asphaltum is used in this way it is absolutely necessary to protect it with a rough board lining such as mentioned above.

It was formerly considered necessary to line acid tanks with sheet lead, but of late years this is rarely done, as the use of lead linings makes the maintenance of acid tanks a very serious item of expense. If the tanks are properly constructed there is no necessity for lining with lead.

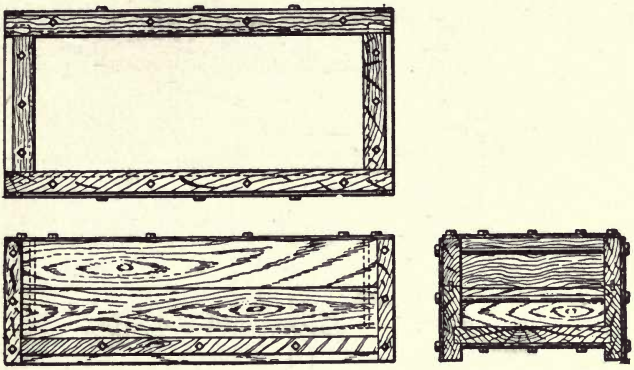

FIG. 24—PLAN AND ELEVATIONS OF ACID TANK

Fig. 24 shows a good method for constructing wooden tanks. It is unnecessary to build expensive tanks for a small plant that is only to be run at irregular intervals. Oil barrels sawed in half, thoroughly cleaned, answer every purpose, provided, of course, the work is of a size which half barrels will accommodate. In building acid tanks one must be guided entirely by requirements in determining size.

Tools for Galvanizing

The tools employed in galvanizing usually consist of tongs of various shapes and sizes, dependent entirely on the shape of the articles to be handled. Perforated baskets of sheet iron for galvanizing small articles, and baskets made from heavy wire cloth can be used to good advantage for a great many purposes, as can wires bent in various shapes. As already suggested under a previ-

ous heading, a great deal of ingenuity may be exercised in constructing special tools for the handling of work of various shapes.

In Fig. 25 we show a few of the most common implements that serve as tools for the handling of a variety of work. A shows a basket made of wire cloth, attached to an iron handle of suitable length, preferably from 3½ to 4 feet. B is a perforated basket

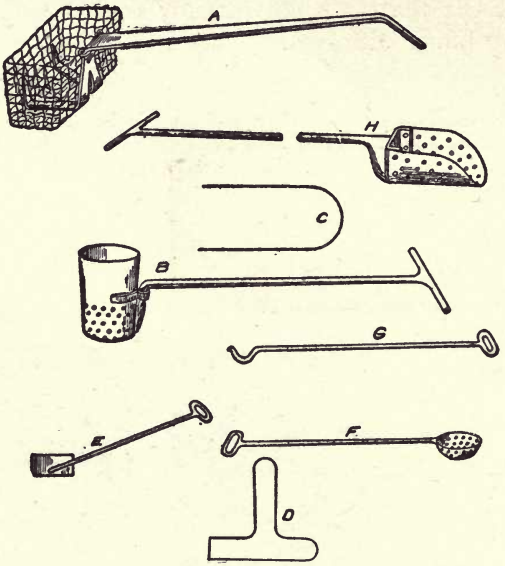

FIG. 25—TOOLS USED IN GALVANIZING

made of sheet iron. This tool is necessary for dipping small articles, such as nails, tacks, screws and many other articles too small to be handled otherwise. Several of the baskets, A and B, should be provided for use when wanted. C is a tool made of common round iron bent in the form of a letter U. This tool is useful for immersing in the molten metal articles too large to be immersed in baskets. D is also used for dipping small articles that can be handled in this way better than in baskets. D is made of wire of suitable size, and it is a good plan to have at least a dozen each of C and D for use when required. E and F are skimmers. The bowl of F is made of No. 16 or No. 18 gauge sheet iron and perforated with ¼ inch holes. It should be provided with a handle at least 4 feet in length, and the bowl should be about 8 inches in diameter. The blade of E should be made of a piece of No. 16

gauge sheet iron from 4 to 6 inches in length by 2 inches in width. The handle should be made of $\frac{3}{8}$ or $\frac{1}{2}$ inch round iron, from 15 to 18 inches in length. G is a tool used for suspending castings in the galvanizing bath that are strung on wires. It should be made of $\frac{5}{8}$ or $\frac{3}{4}$ inch round iron, and be from $4\frac{1}{2}$ to 5 feet in length. H is a scoop for removing dross from the galvanizing kettle. The use of all these tools will be referred to in describing the different operations of galvanizing.

CHAPTER III

The Pyrometer

THE author has had many inquiries regarding the use of a pyrometer in a galvanizing kettle. While it has not been his practice, or generally the practice of other galvanizers, to depend on the pyrometer to any great extent, preferring that the operator should school himself to determine the proper heat of the metal by observation, the introduction of improved instruments for determining more accurately actual temperatures is undoubtedly making converts to new and better methods.

While a reliable pyrometer is without question an advantage to the hot galvanizer, it can never replace the skilled operator. The reason is obvious. In the first place, hardly any two brands of spelter will give the same results at the same temperature. Then again, different classes of work require widely different temperatures of the galvanizing bath. If gray iron castings were to be galvanized a temperature proper for some other classes of work would be found altogether too high. Where a kettle is used for miscellaneous work it is necessary to change the temperature of the metal several times a day. In such cases I have found a pyrometer of very little use. A pyrometer is an advantage on straight work, such as sheets, wire cloth, etc., etc., or, in fact, any class of work that is run continuously day after day. A good pyrometer placed in the kettle from time to time is of great assistance to the operator, however skilful he may be, and it is also of great advantage in caring for the kettle at night and at other times when not in operation.

When the ordinary style of pyrometer is used the stem should be protected from the action of the zinc or it will soon be destroyed. A means by which the stem of the pyrometer is kept from contact with the molten zinc, at the same time giving the same result as if in actual contact, is shown in detail by Fig. 27. The arrangement consists of a piece of 2-inch pipe about 20 inches long with one end tightly closed. The top of the pipe is provided with a bushing having a hole a little larger in diameter than the

stem of the pyrometer. A similar bushing is placed in the pipe about 3 inches from the bottom and the two serve to keep the pyrometer in an upright position. The pipe surrounding the stem of the pyrometer is filled with lead so that when the apparatus is placed in the kettle there is a direct metallic connection between the stem of the pyrometer and the molten zinc. Fig. 26 shows such a pyrometer in position in the kettle.

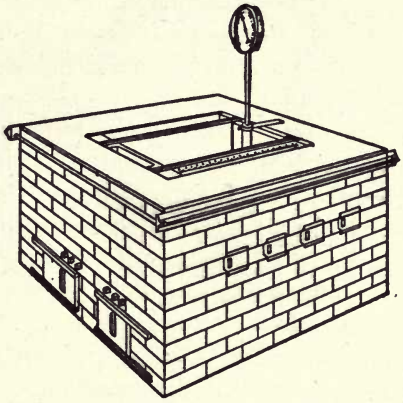

FIG. 26—CORRECT POSITION OF PYROMETER IN FURNACE

The importance of maintaining a safety point in the temperature of the hot galvanizing bath is recognized by everyone, and the question has received the attention of practical and scientific men. A paper presented before the Mechanical Section of the Engineers' Society of Western Pennsylvania in 1912, by S. H. Stupakoff of Pittsburgh, puts this matter so concisely and intelligently that I have asked and received the permission of the gentleman to use the paper in the production of this book. Mr. Stupakoff says as follows:

Considerable difficulty is encountered in galvanizing practice to keep the temperature of the molten metal within the limits which produce a clean and uniform coating on the surface of articles treated by this process. The most suitable galvanizing temperature lies usually about 50 deg. Fahr. above the melting point of the metal bath. Ten or fifteen degrees either way may result in inferior products. The melting point of pure zinc is 787 deg. Fahr. Impurities or other metals, such as lead, antimony, aluminum, etc.,

intentionally added, or accidentally occurring in the mixture, usually lower the melting point; and in such a case it will be found preferable to lower the galvanizing temperature accordingly. This makes us conclude that the temperatures of galvanizing baths require close watching. Ten degrees above or below 850 deg. Fahr. is very little; it would escape the notice of the best of us, unless we

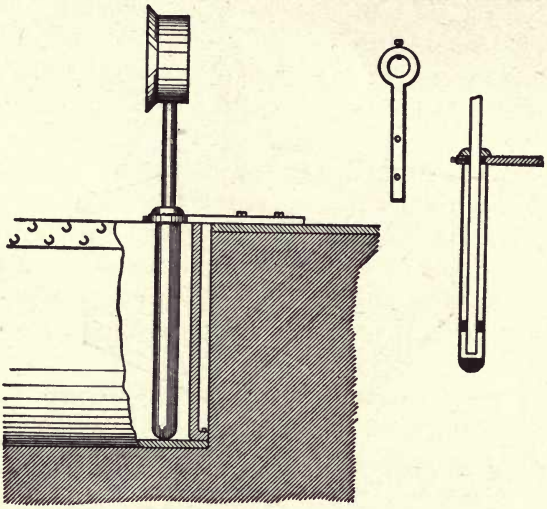

FIG. 27—DEVICE FOR PROTECTING PYROMETER

were guided by the most reliable instruments. It lies beyond the region of the human senses. We may be able to distinguish a difference of 10 or 15 deg. above or below 65 deg. Fahr. when sitting quietly at our studies, feeling uncomfortably cold at 50 or 55 deg. or uncomfortably warm at 75 or 80 deg., but that is about our limit.

This would indicate that our metals are far more sensitive to small variations of temperature than the human body. And more so, if we consider that 10 deg. difference at 65 represents about 15 1/3 per cent., whereas 10 deg. at 850 is less than 1 1/5 of 1 per cent. Unaided by trustworthy temperature measuring instruments it will always remain an extremely difficult matter, even for an expert, to make an approximate estimate of conditions. Though it is conceded that the phenomena invariably accompanying changes of temperature, if intelligently interpreted, may lead

to a successful conclusion of metallurgical processes, it cannot be denied that whatever they may involve they depend upon the personal equation, which cannot be tolerated in modern manufacturing practice.

We receive in this manner undisputable indications of the conditions of the fluid metal in galvanizing practice through the formation of dross, the degree of intensity of its coloring, the behavior of the flux, the intricate motions on the skimmed, clean surface of the metal accompanied by the appearance of variously shaped crystals, like ice crystals on a window pane, and most of all through the appearance of the metallic coating of the galvanized products themselves.

They may remain forever an enigma to the uninitiated, whereas a man who has spent a lifetime at this task may have finally mastered the problem. Nevertheless it is not a rare occurrence that a galvanizing tank in the hands of an expert operator gives out after a few months; and replacing it is always a very costly matter. The cause in ninety-nine cases in a hundred is overheating the metal.

As it is very important that a constant temperature be maintained in the bath, reliable instruments should be provided that will indicate the temperature correctly. This is far more difficult than ordinarily assumed. It may be appreciated to some extent if the assertion of a friend, who has had wide experience in this direction, be accepted as descriptive of the average general conditions in recent galvanizing practice. He assured me that he had tried many heat measuring instruments during the last twenty years, and that not one had given satisfaction. Some failed because they were too fragile, others because they were unreliable from the beginning, some because they were inconstant and changing in time, and still others because they were erratic in their indications. The last of these, which undoubtedly embraces the majority of instruments of the kind, is the least tolerable of the lot. Instead of imparting confidence, they give just cause to distrust, and they invite ridicule of the workingmen to whom they are represented as infallible. I have often run against freaks of this kind. Few of them would indicate the correct temperature within 50 or 100 deg. Some would run along smoothly for a while, and then drop 300 or 400 degrees within a half or three-quarters of an hour and rising again as quickly. Judging from the series of lassitudes and occasional

sudden spurts of activity, they represented anything but existing conditions. Now, what faith could a man have in such an erratic indicating device, if he knows that a tank containing from 10 to 15 tons of molten zinc will not cool more than 19 or 20 deg. Fahr. per hour with all the fires turned off? Let me give an example taken from actual practice.

The temperature of a galvanizing tank, containing about 240,000 lbs. of zinc, dropped 170 deg., from 850 to 680 deg. Fahr. in 27 hours, after the gas fires were shut off. This would indicate an average cooling of only six degrees and a fraction per hour, which is less than a third of the maximum drop that has just been mentioned.

Melting point of zinc (M. P.) ..... 419.5° C.
Specific heat of liquid zinc (S) 0.1275
Mean specific heat of solid zinc (from o° to t°) (S.M.) ..... 0.0906 + 0.000044t
Mean specific heat before fusion at M. P 0.109058
Heat in solid metal at M. P. (from above) ..... 45.75 Calories
Heat in solid metal at M. P. (Richards) ..... 45.20 Calories
Heat in liquid metal at M. P. (Person) ..... 67.80 Calories
Latent heat of fusion (observed) ..... 22.60 Calories
Latent heat of fusion (by 2.1 T rule) ..... 22.40 Calories
Latent heat of fusion (from above) ..... 22.05 Calories
Galvanizing temperature (about) ..... 455° C
Heat required to raise liquid metal from M. P. to 455° C ..... 4.5 Calories
Total heat in liquid metal at 455° C ..... 72.3 Calories
Total heat in liquid metal at 455° C ..... 130.14 B. t. u.
The latent heat of fusion of zinc per pound (Cal.) 22.6
Heat in molten metal at 850 deg. Fahr. is (Cal.) 72.26
and at 680 deg., to which it had been cooled (Cal.) 38.28
hence it has parted at 680 deg. with (Cal.) 33.94
Distributed over the 27 hours, cooling, this is about 1¼ cal. per lb. hr. for the whole mass of 24,000 lb. is about (Cal. per lb. hr.) 300000
Deducting from the above (Cal.) 33.94
The latent heat (Cal.) 22.6
there remains almost exactly 1/3 (Cal.) 11.34

which should be evenly distributed over 9 hours, which is 1/3 of the total time of cooling; the remaining 2/3, or 18 hours, were consumed to turn the liquid metal into a solid mass. Dividing 170, the total drop in temperature by 9, the time in hours, we find 19, or, say, roundly 20 deg. Fahr. drop per hour.

The freezing of the metal should have commenced accordingly, after (hours) 3
it would have been solid throughout after (hours).....21
and the temperature would have dropped during the (hours)...6
remaining, at a fairly even rate per hour of (deg. Fahr.)...20

This is a rough illustration of what takes place in practice. The finer shades of variations have been purposely omitted in this calculation to save complications. The observations cited were made during the winter months; the thermometer indicating about 30 or 35 deg. Fahr. Changes in atmospheric conditions would cause considerable change in the results, as the heat lost by the molten metal is given up to the surrounding air principally by conduction and convection. Differences in temperature and movement, draft, of the air would be the most important factors in such changes.

The question is often asked whether reliable test thermometers can be obtained for the purpose. Undoubtedly they are to be had, but there should be no occasion to use them for checking other instruments of their kind, if such convenient and reliable means can be used as the freezing point of the metal itself. We have no reason to find fault with our commercial thermometers. The better grade can be relied upon to be correct within one-half of a division, even without a certificate; but most confusing results can be obtained with a thermometer, especially with a long stem thermometer, if it is not correctly used. Ordinary commercial thermometers are graduated to be used at full immersion; that is, not only the bulb, but also the entire mercury column is to be exposed to the temperature which is to be measured. However, full immersion is a condition seldom met with when a thermometer is used for technical purposes. In most instances only a portion of the stem can be immersed into the heated medium, and unless the thermometer has been especially constructed for the purpose, grave errors will result. Otto Bechstein says in his description of "Instruments for the measuring of temperatures in technical pursuits" that this error may amount to 50 deg. Cent., and more in long-stem thermometers. I must confess that this is more than I have ever had occasion to observe; but, notwithstanding this, he may be right. As ridiculous as it may seem, it appears, therefore, quite appropriate to recommend to users that they learn the proper use of a thermometer, and, furthermore, when purchasing to fully describe the requirements.

It would seem that, if such apparently simple devices as indus-

trial thermometers require the amount of care in their construction and application as has here been described, other types of heat-measuring instruments, which command more extended ranges and which see a more severe use, can scarcely be expected to be entirely free from objectionable features. Each type has its scope, each must be used with due care and with each set rules must be intelligently observed to obtain satisfactory results in their application.

The most important features of some of them have been referred to; it was impossible to enter into the details of all the instruments, nor could all their useful application in the large number of processes of the metal industries be described at length in a paper of necessarily limited length. To cover the entire ground would fill a large volume and require a series of lectures. The discussion of the subject may bring forth many points of interest which have not been mentioned.

CHAPTER IV

Materials Used in Hot Galvanizing

THE materials used in galvanizing are slab zinc (spelter), pig lead, white and gray granulated sal ammoniac, zinc ammonium chloride, muriatic, sulphuric and hydrofluoric acids, coke (if side fired kettles are used), oil, glycerine, and aluminum properly mixed for fluxing metal.

Spelter

We cannot, with fairness, express a preference for any particular brand of spelter; but on general principles we do recommend the use of Virgin spelter smelted by a reliable firm. We do not recommend the use of what is commercially known as "Remelt" spelter by those who are not familiar with this metal. While most Remelt spelter is run down from sheet zinc, there are several brands on the market which have been recovered from zinc dross by those who have not the facilities for properly doing the work. We do not wish to go on record as claiming it impossible to recover good metal from zinc dross. In fact, we have in mind a brand of spelter that is recovered from zinc dross which gives as good results, both in quality of the work and economy, as the best brands of Virgin spelter. Great progress has been made in the last few years toward the recovery of galvanizing by-products of all kinds, and materials at one time considered worthless and consigned to the waste heap are now valuable.

No infallible rule by which the layman may determine the quality of spelter can be given. The only positive way is by analysis. In a general way the quality of spelter may be determined fairly well by breaking slabs and observing the fracture. If the fracture shows a bright, regular and large granular face it indicates that the spelter is of good quality, but if the fracture shows dark, small granules it indicates quality that is not the best. A magnifying glass, when applied to a freshly broken slab of Remelt spelter, will often reveal small black particles acting as wedges between the granules. These particles are foreign matter principally, and therefore lessen the value of the spelter as well as

acting as a detriment in melting and coating operations. However, if the policy of buying only Prime Western or Virgin spelter is followed, one can be sure that no dross is introduced into the galvanizing bath in the spelter, as would be the case if Remelt spelter, reclaimed by crude methods from zinc dross, was used.

Lead

Scrap lead will answer every purpose for use in the galvanizing kettle as described under the heading "Filling a New Kettle," but if it is necessary to procure pig lead for this purpose it is best to buy what is known as "hard lead."

White and Gray Granulated Sal Ammoniac

These chemicals play an important part in the process of hot galvanizing; the grade known as "gray granulated" sal ammoniac being used to form a flux on the surface of the zinc, which flux is necessary to facilitate the proper coating of the work and to retard the oxidation of the molten zinc by excluding the air. White sal ammoniac is used to sprinkle on the surface of the molten metal as the work is withdrawn. Some galvanizers use the white for both purposes. These chemicals are an important item of expense in the cost of hot galvanizing and care should be exercised against buying inferior grades. The best sources of supply can only be learned by experience, as it would be manifestly out of place for the author to express a preference in this book for the product of any particular manufacturer located either in this country or abroad.

Zinc Ammonium Chloride

The use of zinc ammonium chloride on the galvanizing bath as a substitute for gray granulated sal ammoniac is comparatively a new idea. As a matter of fact, it is only used at this writing by comparatively few galvanizers. We give it the preference over gray granulated sal ammoniac, not by reason of economy, but from the standpoint of comfort. The fumes of zinc ammonium chloride rising from the surface of the molten zinc are less disagreeable to the operator and less destructive than the fumes of sal ammoniac, and, in our opinion, it gives much better results than the sal ammoniac.

Muriatic, Sulphuric and Hydrofluoric Acids

These acids are readily obtainable in all important trade centers and are so common that no extended reference regarding them is necessary.

Coke

Coke is the only practicable fuel that can be used on kettles of the character shown in the preceding pages. While it is possible to use what is known as foundry coke for heating a galvanizing kettle, it is unsatisfactory, and the best results are obtained with that produced in making illuminating gas, commonly known as gas coke, which may usually be purchased at a lower figure.

Oil

Oil is commonly used in the galvanizing process on the surface of the water in which the work is cooled after it has been taken from the molten zinc. While some galvanizers use different grades of fuel oil, we have found that better results are obtained by using what is known as "mineral lard oil."

Glycerine

Glycerine is used in a small plant in very limited quantities. Therefore, the small operator can depend on his local druggist for what is necessary. In large plants it is usually bought from the manufacturers in iron drums holding from ten to twelve hundred pounds.

Aluminum

This metal is quite commonly used in galvanizing baths to make the metal more fluid and improve the appearance of the work. Its use has become so common that several concerns now make a business of manufacturing aluminum alloys or fluxing metals for galvanizing purposes, selling them under various trade names. The different manufacturers of these alloys have their own methods of application; consequently, we shall not attempt to give any hard and fast rules for the use of fluxing metals in a galvanizing bath.

CHAPTER V

Pickling

AS THE first operation in any process of galvanizing or tinning is to properly prepare the work to take the coating, we will give that our first attention by describing the different methods. Many large concerns use the mechanical pickling apparatus shown in Figs. 28 and 29.

There are several agencies that may be employed in preparing work for galvanizing. Sulphuric, muriatic and hydrofluoric acids are all valuable agents for this purpose, and the ones most commonly employed.

The cleaning of work with acids preparatory to coating them by any process is known as "pickling." Pickling means the removal of scale and other foreign substances from the surface of the metals by the chemical action of the acid. If the material to be cleaned is simply soaked in acid the chances are that too much of the metal will be dissolved, as the action is not uniform on account of the varying density of the acid, and the cleaning is both uncertain and uneven. Agitation is therefore desirable. This was originally and still is to a great extent accomplished by hand, although many of the large manufacturers of galvanized sheets, galvanized wire, galvanized pipe, tin plate, cold rolled steel and cold rolled shafting employ mechanical methods to procure proper agitation of the material in the pickling vats because hand pickling of these materials was always insufficient and inefficient. As a pickling machine brings mechanical action into play to the extent that the material is pickled with about one-half of the acid and labor required in hand pickling, we consider it our duty to refer to it in this article as well as to illustrate it. The best result is obtained by moving the material being cleaned through the acid with a predetermined velocity. By proper mechanical means the sheets (if such are being pickled) are separated and shifted sufficiently to allow the acid to enter between them and prevent their sticking together. The acid washing over the surface has, in conjunction with the loosened particles of scale, a scouring action which thoroughly cleans the sheets. The uniform action of the

acid upon the surface is assisted by thoroughness of the agitation, which does not allow acid layers of different density to form. In pickling sheets this feature is of extreme importance. If they are

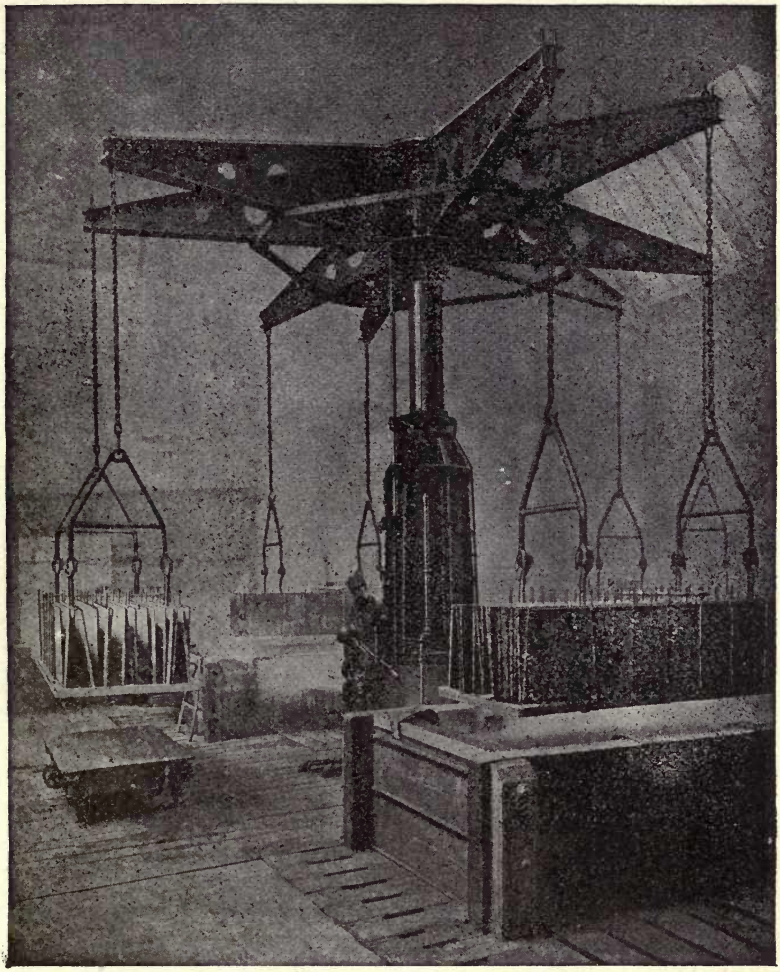

FIG. 28—VIEW OF MECHANICAL PICKLING EQUIPMENT

immersed in a vat of improperly agitated acid, layers of varying density form so that before the upper parts of the plates are properly pickled the lower parts are over-pickled. The above is also true with regard to the cleaning of pipe by mechanical means. If

pipe that is intended for galvanizing is kept in agitation in the acid vat by mechanical means, the cost of acid and labor is materially reduced and the work much better done.

While mechanical pickling methods have not been applied to any great extent to the cleaning of castings or other small articles, they might be applied to marked advantage in many cases, and the ideal mechanical method is one that keeps the material being pickled in motion instead of one that simply agitates the acid.

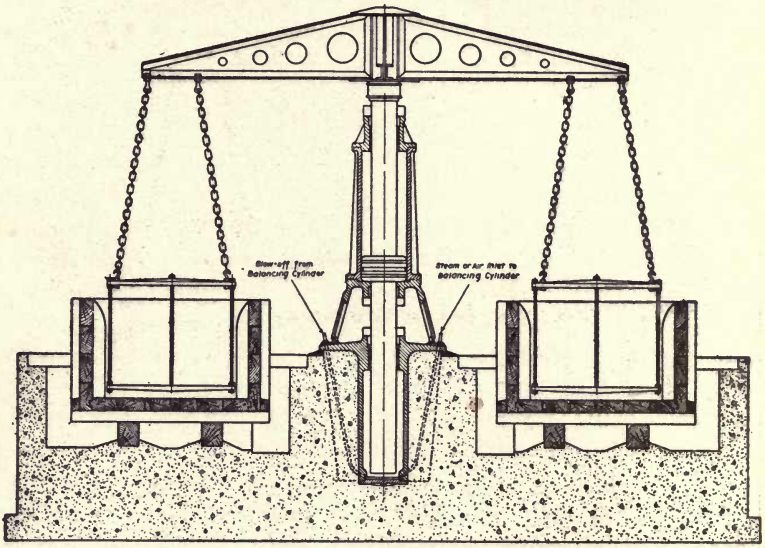

FIG. 29—A SECTION SHOWING ARRANGEMENT OF MECHANICAL PICKLER

Acid consumption per ton of material depends upon many circumstances. Purity and strength of acid, temperature of the pickle, thickness of scale, etc., govern acid consumption.

The pickling of certain classes of material, mainly sheets for tinning or galvanizing, is technically known as "black pickling" and "white pickling." Black pickling means the removal of the heavy oxide formed during the hot rolling process. White pickling means the removal of the film of oxide resulting from the second annealing. To have the work properly done, acid must wash over all the surfaces all the time; otherwise, as before stated, the material is not pickled uniformly. In pickling sheets for galvanizing or tinning the change from one acid vat to another must consume

very little time; otherwise, the product will accumulate dry acid and oxide.

What we have said thus far regarding pickling applies, of course, more particularly to large plants than to the ordinary jobbing plant handling miscellaneous work. We will, therefore, treat the subject from the standpoint of ordinary requirements, as, in addition to acids for preparing work for galvanizing and tinning, we have the rolling barrel and the sand blast, both of which can be employed to good advantage, especially the sand blast. Acids, however, are an absolute necessity, while the rolling barrel and the sand blast are simply valuable auxiliary agents.

Removing Scale with Sulphuric Acid

Articles of sheet iron or steel are covered to a greater or less extent with scale, which must be removed completely before zinc will adhere to them. To accomplish the removal of this scale, and also the removal of rust, solutions composed of sulphuric acid and water of different degrees of strength are employed. Probably a solution composed of one part sulphuric acid to twenty parts of water, reckoned by weight, at a temperature of 150 degrees F., will answer for as great a variety of requirements as any, although the strength and temperature of the solution may be safely varied in the hands of a skilled operator. The trouble to be guarded against is over-pickling, by which we mean subjecting the material to a solution that is too strong, or too hot, or for too long a time. The effect of over-pickling is apparent, as it results in leaving the material full of seams, or when it happens to work that has been threaded, in the entire or partial destruction of the threads.

The length of time required to accomplish the work varies with the thickness of the scale. In many cases it is necessary to remove thick spots of scale with some sharp-pointed tool. The shank of an old file sharpened and hardened answers this purpose very nicely. Patches of heavy scale are often found rolled into the heavier gauges of sheet iron and steel, and they are nearly always present on forged work. As that part of the article first becoming cleaned by the action of the acid would be injured if allowed to remain in the acid long enough to remove the heavy scale it is necessary to use a tool of some sort to loosen the spots of heavy scale. Material having an uneven coating of scale should be cleaned in a weaker solution than that having an even coating or that

having a light scale. The reason is that the part of the stock which is first cleaned will be over-pickled before the parts having the heavier scale are clean.

Where large quantities of wrought iron and steel products are pickled or cleaned with sulphuric acid, which must be heated to perform its function to best advantage, the fumes arising from the pickling solutions are very obnoxious and the conditions in the pickling rooms, and sometimes adjacent departments, in some of the large plants are almost unbearable, especially in the late fall, winter and early spring.

With the view of overcoming the objectionable features of sulphuric acid, without at the same time sacrificing efficiency or adding considerably to expense, several substitutes for pickling and cleaning wrought iron and steel have been placed on the market in recent years.

"Kleanrite" is referred to by the manufacturers as a "powdered compound, soluble in water." Its use requires no change in the pickling equipment. It is used in a solution made up of 1 pound of "Kleanrite" to 4 or 5 pounds of water, or may be varied to suit any particular or unusual conditions in pickling. For quick results the solution is heated to 150 to 200 degrees F. It is claimed to pickle without burning, and without pitting the metal. It does not exhale any disagreeable or destructive fumes such as are present when pickling with sulphuric acid.

"Edis Compound" is another substitute for pickling acid. It is manufactured in the form of dry cakes which are simply dissolved in water and brought up to about 200 degrees temperature; in other words, it is used just about the same as acid, but being in the dry cakes it is very convenient and pleasant to handle, and does not start to act on anything until it is dissolved in water.

When the work has been pickled free from scale and rust and is perfectly clean, it should be stored for future use in a tank containing water enough to cover it completely. A in Fig. 3 designates the tank to be used for pickling the material to remove scale, and B in the same illustration denotes the storage tank.

Rust and scale may be removed by the aid of muriatic acid, properly diluted with water, although not as economically as with sulphuric acid, but in cases where only small quantities of forgings or articles made from sheet iron or steel are handled the sulphuric acid solution can be dispensed with entirely and the operator

can use the muriatic acid solution exclusively. A safe "pickle" of muriatic acid is one part acid to four parts water, liquid measure. If it should be desirable to hasten the cleaning process when using the muriatic solution it may be heated to a temperature of 150 degrees F., although the material must be carefully watched to prevent over-pickling.

Cleaning Sandy Castings with Sulphuric Acid

Castings that are sandy may be cleaned by pouring over them a cold solution of sulphuric acid and water, one part acid to six of water. Place the castings on an inclined platform and wet them frequently with the solution. Continue this operation until the sand is loosened, when the castings should be removed and water dashed over them to remove all loose sand. This process is generally known as "foundry" pickling, and was extensively used at one time. Castings that have been subjected to this treatment too long will be covered with what appears to be a gummy or greasy substance, and will not take the coating of zinc properly unless they are left in the metal a long time, and even then they will not be nicely coated, but will be rough and covered with thick patches of metal. They will not have the smooth finish which properly prepared castings have.

Cleaning Castings with the Aid of Hydrofluoric Acid

Hydrofluoric acid has come into almost general use among galvanizers for the removal of sand. There is very little danger of its injuring the iron, and as it dissolves sand readily, it is the ideal acid agent. We have subjected an extremely sandy casting to the action of a cold, weak solution of hydrofluoric acid for 3 or 4 days before the sand was entirely dissolved without any perceptible injury to the casting itself. Many galvanizers bring the temperature of their hydrofluoric pickle to anywhere from 75 to 200 degrees F. We believe that it is a serious mistake to make this a common practice. There are occasions when it is absolutely necessary that the work be accomplished in the quickest possible time; but as a general rule plenty of time may be taken for the removal of the sand, and it is done much better and more economically and satisfactorily by the use of a weak, cold solution. In our regular work we employ sufficient tank capacity to permit of the castings remaining in a weak, cold solution from 8 to 24 hours. Castings

prepared this way for galvanizing will take the zinc readily, cause the formation of less dross in the galvanizing kettle, and have much better commercial appearance than castings prepared quickly in a hot, strong solution. A solution composed of one part acid to ten parts water has very little tendency to injure the iron if used cold, although we often allow the solution in our tanks to fall much below this strength. As a matter of fact, we make up a new solution only at long intervals, simply adding a little acid and a little water from time to time as necessary. We have found this formula very efficient for a quick pickle:

Hydrofluoric acid (30%),	6 gallons
Muriatic acid,	4 "
Water,	40 "

This solution should be used warm, not hot. The action of the muriatic acid hastens the removal of the sand, but is not violent enough to injure the casting.

CHAPTER VI

Water Rolling, Tumbling and Sand Blasting

THERE are many times when the tumbling barrel will be found of great value in the cleaning process; especially in a plant devoted to miscellaneous work or to the galvanizing of malleable or gray iron castings. It not only facilitates the process of removing sand from such castings, but can be employed to good advantage in removing heavy rust or scale from forgings; thus overcoming to a great extent the danger of over-pickling, as well as the disagreeable features connected with the use of acids. Castings of a character that permit of their being tumbled can often be put in proper shape to receive the zinc coating without subjecting them to the action of acid, and, in any event, castings that have been tumbled only require a short time in an extremely weak solution of hydrofluoric acid.

Water Rolling

A piece of wrought iron from which the scale has been removed by the use of acid will not have the smooth and perfect coating that it would have if the scale was removed by rolling. The same is true of malleable iron castings. The best and most perfect results are obtained by giving the castings a thorough tumbling in gravel and water, which operation brings their surface to a state of smoothness only equaled by buffing or polishing. Malleable castings on which it is desired to obtain a fine finish should invariably be given this treatment. It is also necessary that patterns from which castings are made that are designed to be tinned should be finished to produce the smoothest surface possible. This will help to shorten the tumbling operation.

Some tinners not only roll their castings in gravel and water, but for the purpose of obtaining a smoother surface than can be obtained by this method they roll them with scraps of leather, the entire operation often requiring 30 or 40 hours. Water rolling is so common and so thoroughly understood that we consider it unnecessary to give detailed instructions regarding the apparatus to be used or the methods employed. There are several concerns who

make the manufacture of rolling barrels for this purpose a specialty, and the cheapest method to adopt when equipping a tinning plant with wet rolling barrels is to buy the outfit complete from a manufacturer who has made a study of the business.

Dry Tumbling

Iron castings as they come from the foundry always have more or less sand upon them and castings of large size or peculiar shape often have patches or pockets of sand burnt into their surface, which cannot readily be removed by pickling. One cheap and efficient way of removing this sand is by dry "tumbling," and this method has been used for years by iron foundries to clean their castings, and, at the same time, to improve their appearance by brightening and smoothing their surfaces, therefor dry tumbling serves two important purposes, cleaning and polishing, and all who are familiar with foundry practice are more or less familiar with tumbling. There are several types of dry tumbling barrels on the market made by different manufacturers, but most of them are cylindrical in form and the most improved outfits are designed to be fitted with a system of pipes and fan for removing dust from the barrels. This dust would otherwise go off in the room and is sometimes quite objectionable.

Most castings are of such shape that they could not be thoroughly cleaned or polished in the tumbling barrel, unless some smaller objects were tumbled with them, which would work into the holes or identations on their surface. For this purpose iron stars, commonly called jack stones, diamonds or cubes are used, all of which in foundry parlance are called "shot." Very small castings with fairly smooth surfaces can oftentimes be tumbled clean without the use of shot.

To load a tumbling barrel put in first a thin layer of shot and then a layer of castings and continue in this manner, one layer upon another, until the barrel is nearly filled. Some space must be left for the castings and shot to move about in as the barrels revolve. The friction caused by this moving or "tumbling" cleans the castings. If fragile gray iron castings are being tumbled, too much space must not be left in the barrel, as such castings would be broken by the shock of tumbling with too much force. One-third shot and two-thirds castings (by bulk) is about the right proportion for ordinary tumbling, but the proportion should be

changed to suit the individual requirements of each lot of castings using more shot for hollow castings, or castings with a very uneven surface and less for plain castings with comparatively smooth surfaces. After the barrel is loaded and started very hard pounding of its contents will warn the operator that the barrel is not properly packed and castings may be injured if allowed to continue tumbling under these conditions.

In tumbling for galvanizing let the castings remain in the barrel until all sand possible is removed without injuring them, as this is the most important object of tumbling for galvanizing. Practice makes perfect and with intelligent study of the problem an operator can, after a time, tumble castings so clean that they will require very little, if any, pickling before galvanizing. The cleaning of many kinds of work for galvanizing is greatly simplified by the use of the tumbling barrel. Old rusty chains and castings or wrought iron forgings which are badly rusted can usually be cleaned to good advantage in this way. Old paint can also be removed from articles which can be tumbled much easier and better in many cases by tumbling than by any other means. In addition to cleaning cheaply, tumbling also makes the surface of castings smooth, which greatly improves the appearance of the galvanizing.

The Wet Tumbling Barrel

The barrel is constructed in accordance with the plan shown in Figs. 30A, 30B and 30C. The points where in this barrel differs from the ordinary wet rolling barrel are: that it is built very heavy and strong, is provided with valves for the escape of gases generated by the chemicals used, and the opening where the barrel is filled is arranged to close tightly.

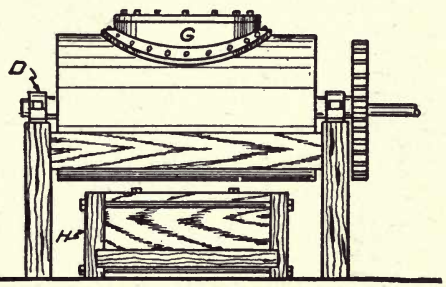

FIG. 30A—TUMBLING BARREL

For general work we prefer a barrel 48 inches long and 24 inches in diameter. The shell we make of $\frac{3}{8}$-inch boiler iron, and use cast iron heads $1\frac{1}{2}$ inches thick. The manhole cover we make 1 inch thick, and have it well ribbed to give additional strength.

Fig. 30B is a plan view of the barrel, and it also shows the receiving tank H, designated in the ground plan, Fig. 51, as B.

Fig. 30A is an elevation of Fig. 30B.

Fig. 30C gives the details of the barrel, in which A is an end view of the trunnions B and C, and D is a view of the pillow blocks supporting the barrel, and E is the pillow block for the pinion shaft; F is a valve for the escape of gas, and G is a view of the end of the barrel on which the valves F are placed, while H shows the rolling barrel cover.

Preparing the Castings for the Tumbling Barrel

The details of cleaning having been carefully attended to, place the castings in the tumbling barrel, together with a quantity of ordinary iron "stars," such as used in dry tumbling, being careful to load the barrel in such a way as to prevent breaking or wearing the corners of the castings. Tea kettles should be filled full of stars or shot before placing them in the tumbling barrel, and light, delicate castings should be packed tightly enough to prevent breaking. Stars or shot sufficient to fill the barrel about one-fourth full will be found the most desirable quantity for ordinary work, although on hollow ware much more are needed, or enough to fill up nearly all the vacant space. After the barrel has been loaded in the way described, put in water sufficient to fill it about three-fourths full, then add 15 pounds of commercial muriatic acid and 2 pounds of gray granulated sal ammoniac. The barrel is now ready to be closed and started, presuming that the operator has examined the valves to see that they are in perfect working order previous to loading the barrel.

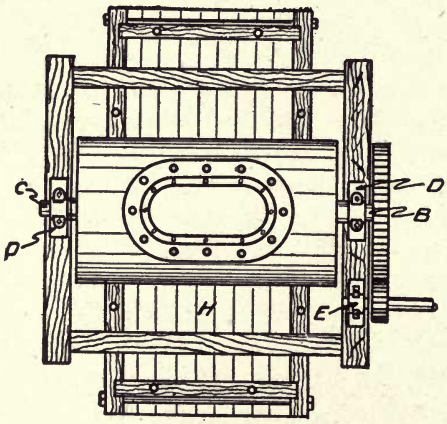

Fig. 30B—Top View of Tumbling Barrel

After the barrel has been in motion from 5 to 15 minutes, de-

pending on the temperature of the water used, there will be formed sufficient gas to cause the valves to open. The escape of gas will be accompanied by quantities of the solution, and the end of the barrel on which the valves are placed should be inclosed, unless the barrel is set up in a room itself.

The time which castings should be rolled in this solution varies from 2½ to 5 hours. Soft, smooth castings will take a nice coating after a rolling of 2½ hours, while to obtain the same results on hard iron, iron cleaned by the use of sulphuric acid, hollow ware and tea kettles and castings having a black lead facing, 5 or more hours in the barrel may be necessary. It is safe to say that 3½ hours is sufficient to properly roll ordinary castings if the barrel turns 40 revolutions a minute. For hollow ware, tea kettles and very delicate castings the barrel should not attain a speed of over 30 revolutions per minute. After the castings have been rolled in the solution the required time, open the barrel and cover its contents with water immediately. Do not let time be wasted in getting the castings covered with water, as a slight exposure to the air will cause them to oxidize and prevent them from taking the tin. If the castings are properly prepared—that is, if they have been rolled in the solution long enough—they will be in such condition after rinsing that they will not soil a white cloth, rubbed on their surface, to any extent.

Should it be found that the castings are not properly prepared (which is done by putting one or two of the pieces through the regular treatment), the barrel should be re-charged by adding 6 pounds of muriatic acid and allowed to run about an hour longer. In rolling castings plans should be made to complete the work before the stopping of the power at noon and night. 3½ hours being required on an average to prepare iron in the rolling barrel, it is easy to arrange to start the barrel in time to complete one batch in the morning and one in the afternoon. This would furnish work enough to keep two hands engaged, although one set of kettles would take care of all the iron that could be prepared in a barrel of the size we show; viz., 2 feet in diameter by 4 feet in length.

If the castings are quite soft and clean three batches may be prepared in ten hours, in which case the second batch should be in the barrel in time to give it at least one hour's rolling before the power is stopped at noon. When a batch of iron is left in

the barrel during the noon hour, leave the barrel closed, and in a position where one of the valves will be up, with its opening above the solution in the barrel. Unless this is done the valves may open and allow the solution to escape, necessitating the re-charging of the barrel. If a batch of castings is not completed in season, to remove it to the storage tank before the time for stopping the

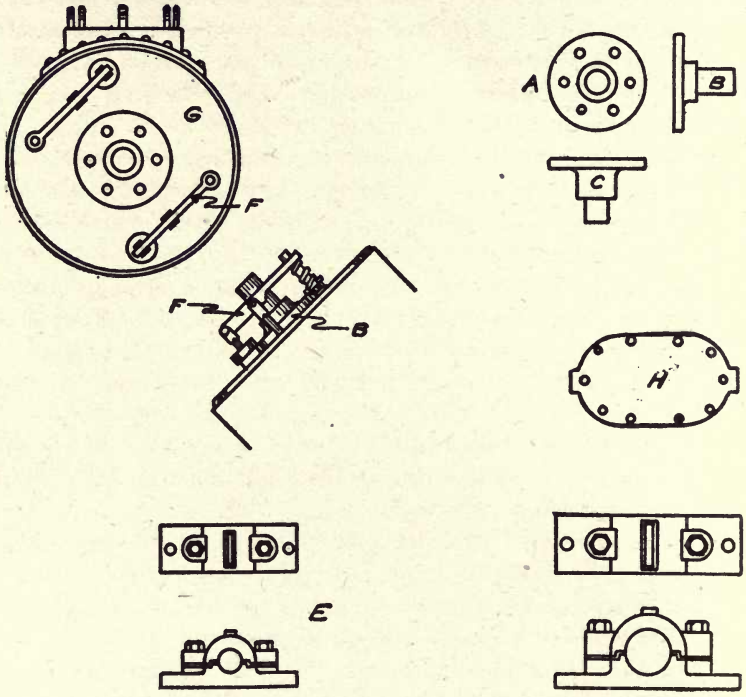

FIG. 30C—DETAILS OF TUMBLING BARREL EQUIPMENT

power at night, remove the cover, and allow enough fresh water to flow into the barrel to displace at least half of the solution, and leave it in that condition until morning, taking care that the valves do not leak, that the iron is completely covered, and that the water is not left running, as iron will rust in running water even if the water covers it.

In rolling a batch of castings it will often be found that a black foam will rise to the surface of the solution when the barrel is opened. This is formed by the iron dust left on castings that are cleaned by dry tumbling, and it will also be found when

preparing castings that have been faced with foundry facing of any sort. When this foam or scum is present, let water flow into the barrel, with the opening in a position that will allow the objectionable matter to float off. The first one or two batches prepared in a new barrel are liable to give trouble in tinning unless the inside of the barrel, with the shot to be used, is cleaned with a strong alkali solution. The simplest way is to put the shot into the barrel, and, after filling it about half full of strong, hot alkali solution, close the barrel and allow it to run an hour or more, after which the interior of the barrel and the shot used should be rinsed with plenty of clean water.

It sometimes happens that castings are encountered which have a ground work of delicate design into which the sand has been burned. If such castings are placed in the rolling barrel with a good quantity of shot and given two or three hours' rolling in a solution of hydrofluoric acid and water, 1 part acid to 75 or 100 of water, they will be cleaned very nicely. When this is done let the hydrofluoric solution run out of the barrel before charging it with the regular solution of muriatic acid, sal ammoniac and water.

The operator must bear in mind at all times that as a safeguard against accident he must see that the valves on the rolling barrel are kept in good working order. These valves should be adjusted to open at a pressure of 40 pounds. If, by reason of a leak in any part of the barrel, gas is not generated the work will not tin properly. Do not approach the barrel with a light at any time when the gas is escaping, or at any time when the gas is being generated in the barrel. If after stopping the barrel it is found that the valves leak, as they may from becoming clogged, stop the leak, as the solution will escape, thereby allowing the work to oxidize. Badly oxidized castings will not tin. The solution contained in tank F, Fig. 51, is calculated to remove a light oxide, but castings that are heavily oxidized must be re-rolled.

Storing the Castings After Tumbling

As soon as the operator has determined that the castings are properly rolled for tinning he proceeds to dump the contents of the tumbling barrel into the receiving tank, located directly under the barrel. The cubic contents of this tank should be about one-third greater than the rolling barrel. From this receiving tank

the castings should be removed to the storage tank designated C in Fig. 51. A good-sized coke fork is best for handling the castings from tank to tank, as it lets the shot or stars fall to the floor separate from the castings.

In placing the castings in the storage tank care should be taken to have those with depressions or cavities go under the water with the openings up. In other words, castings of a shape that would retain pockets of air under the water should be so placed that no air can be retained. If air is retained there will be a rusty place formed on the casting to which the tin will not adhere. The water in storage tank C, Fig. 51, will in a short time become charged with the acid solution from the rolling barrel unless it is changed frequently. If much acid is present in the water it will impair the action of the alkali solution into which the castings pass directly from this tank. If a few pounds of the alkali selected for use (caustic soda or soda ash) is added two or three times a week to the alkali solution, it will do its work properly for some time, although it is best to clean out the tank and make up fresh solution once in two weeks when it is in constant use.

Cleaning Work with the Sand Blast

While the art of sand blasting is old, its use in preparing material to be galvanized or tinned is comparatively new.

Not so many years ago the process of tinning common gray iron was considered a great secret. As a matter of fact, there were only one or two concerns able to do it on a commercial basis, and their operation was confined to comparatively small castings. The methods employed were complicated and expensive. The use of the sand blast has made the tinning of gray iron a simple matter, especially in the case of unusually large or fragile castings.

While the best commercial appearance is still obtained by use of the wet rolling barrel, there are many kinds of castings that it is impracticable to prepare in that manner owing to their size or delicate construction. To obtain even fairly economical time results with the water rolling barrel it is necessary to have it revolve not less than 35 or 40 revolutions per minute, and even with this speed it takes no less than 3 hours to properly prepare a batch of castings for tinning, and often a much longer time. On the other hand, the sand blast barrel will prepare a similar batch of castings in from 15 to 20 minutes.

Cold galvanizing as well as Sherardizing can be done on work coming direct from the sand blast, practically eliminating the use of acids, and a much brighter coating is obtained. As acid works more or less into castings in the cleaning process, even its partial elimination is another distinct feature in favor of sand blasting for any process of coating.

Another feature in favor of the sand blast is that old work can be thoroughly and quickly cleaned by this method. It is our practice to use a pressure type of hose machine in the cleaning, for hot galvanizing of old anchors, old anchor chain, and in fact old material of a heavy nature of almost every kind.

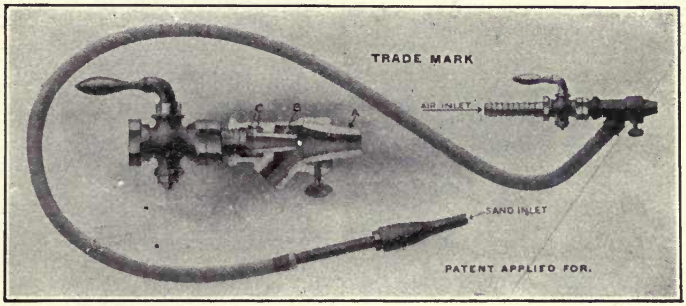

FIG. 31—A SIMPLE TWO-HOSE TYPE OF SAND BLAST

The large variety of shapes and weights of castings makes it impossible for us to give a definite time for cleaning by this method. In a general way we will say that such articles as food choppers, saddlery hardware, etc., when cleaned in a sand blast barrel will require from 10 to 15 minutes, the consumption of free air per minute being 135 cubic feet at 60 pounds pressure, while heavier castings or old work that is badly rusted may require a considerably longer time. For steel castings and forgings a higher pressure will give the best results. This applies to both the hose and the automatic machine type.

The value of the sand blast for plating plants in general is only beginning to be appreciated, and while it does not entirely eliminate the use of acids, it goes a long ways in that direction and is one means of making working conditions in a hot galvanizing plant, which are bad enough at best, much more endurable.

That the subject of sand blasting and the apparatus referred

to may be better understood, we refer to the same herewith more fully. The term sand blast in its simplest form means a stream of sand and air under pressure. In this condition the sand gathering velocity as it is carried along with the air strikes the object in its path with great force. The cutting action of the blast is greater when the blow is slantwise rather than straight against the object.

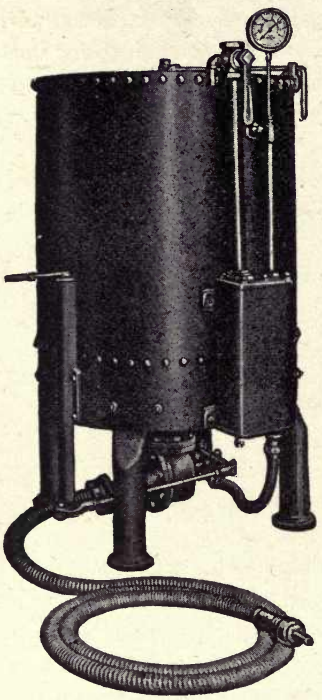

FIG. 32—SINGLE HOSE TYPE SAND BLAST APPARATUS

A simple form of sand blast device can be made from a Y pipe fitting, using regular stock fittings to complete the job, but the action of the blast would destroy the several parts after a few hours' service. Far better satisfaction will be obtained by purchasing an outfit like that shown in Fig. 31. One popular and serviceable suction sand blast outfit consisting of cast iron nozzle with removable air tip, easily replaceable hard iron blast tip, air valve, sand hose, sand blast helmet and gloves, costing not over $25.00. In this type of apparatus the end of the sand hose is placed in a pail or pile of sand and the air turned on at the nozzle.

The next, and most widely-known system, is the pressure or single hose type, where the sand is placed in a closed tank and air admitted to the same under the same initial pressure as that to be used in the blast. In this machine, see illustration, Fig. 32, there is a mixing chamber at the bottom into which the sand is fed through a valve, and the sand mixing with the air which is admitted through a separate opening is discharged through a single hose. At the outer end of the hose is a hard iron nozzle holder, having means for replacing the hard iron tip which wears away very rapidly. The hose must be specially made for sand blast use, the core being composed of practically pure rubber.

The present tendency in sand blast practice is toward higher air pressures, say 60 pounds, using smaller nozzles and hose. It is easier for the operator to handle this apparatus than the more cum-

bersome where lower pressures are used. The maintenance cost is also less. A very satisfactory outfit consists of tank, one-inch hose and ¼-inch blast nozzle, the consumption of free air at 60 pounds pressure being about 67 cubic feet and the power required to compress the air approximately 10 H. P.

The present tendency is to get away from the hand operated blast owing to the reluctance of men to follow this work continuously. Accordingly self-contained, dustless machines have been designed which handle tons of material in a day. These are made in the form of a rotary table, a sliding table or planer type and revolving barrel.

Sand Blast Rolling Barrel

For cleaning small and medium-sized castings, forgings, etc., the sand blast rolling process is to be preferred in many ways. A popular type is shown in Fig. 33.

The self-contained feature confining the blasting operation and recovery of abrasive to the inside of barrel makes it a dustless, as well as a more efficient, method.

The process is entirely automatic after the work is placed in machine, and the operator is at liberty to attend to other matters if he so desires.

Unlike the tumbling mill running approximately 40 R.P.M., the sand blast rolling barrel revolves 2 R.P.M., making it possible to clean fragile castings without rounding the corners, etc.

This method has proven valuable in cleaning letters or ornamental design work on castings, the slow movement of barrel prevents defacement and the blast removes all dirt and cleans them perfectly.

The inner barrel B in Figs. 34A and 34B is made from heavy sheet steel, one-half inch thick, having a number of holes in same which allows the sand, after coming from the blast nozzle F and striking castings, to fall through at bottom of inner barrel B to outer shell A. As the barrel revolves (direction of arrow) the sand or grit falls into buckets C and is carried to the top of the barrel, where, by its own gravitation, it falls back through the holes which it entered, passing through screen E, removing all foreign substances, into sand-hopper D, ready to be used again.

G is the exhaust pipe for removing dust, H the slide valve in hopper, I the cast steel hopper support, J the petcock for drip, K the compressed air inlet, L the exhaust outlet.

While it is possible to do sand blasting in an open space, yet the dust arising from the operation is so objectionable that it is customary to provide a room for this work, the same to be connected to an exhaust fan having capacity sufficient to change the air in the room not less than five times every minute. Fresh air

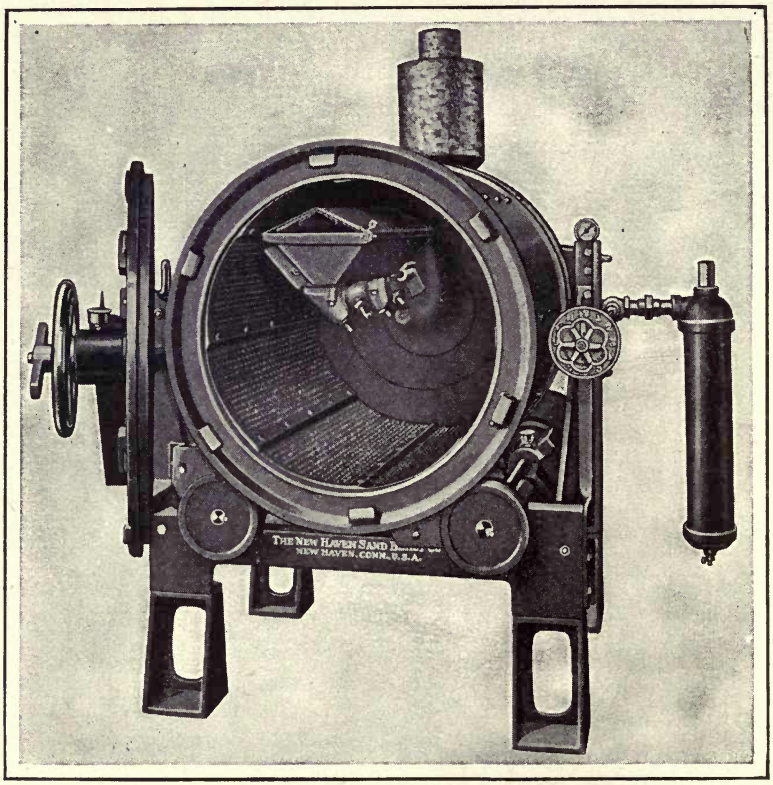

FIG. 33—SELF-CONTAINED SAND BLAST BARREL

must be admitted at a point as far distant from the exhaust connection as possible. The smaller the room the better, for less power will be required to run the fan. The walls of the room are usually of wood, nailed on and easily renewed as occasion demands. A most satisfactory lining is discarded fire service hose, which should be split and, with the inner side facing out, nailed to the siding. The operator must be provided with a helmet and should also use a respirator. Leather gloves are also a necessity.

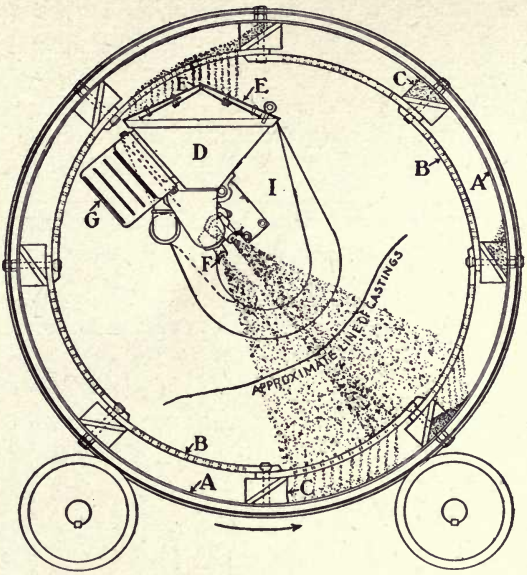

FIG. 34A—FRONT VIEW, SHOWING DETAILS OF SAND BLAST BARREL

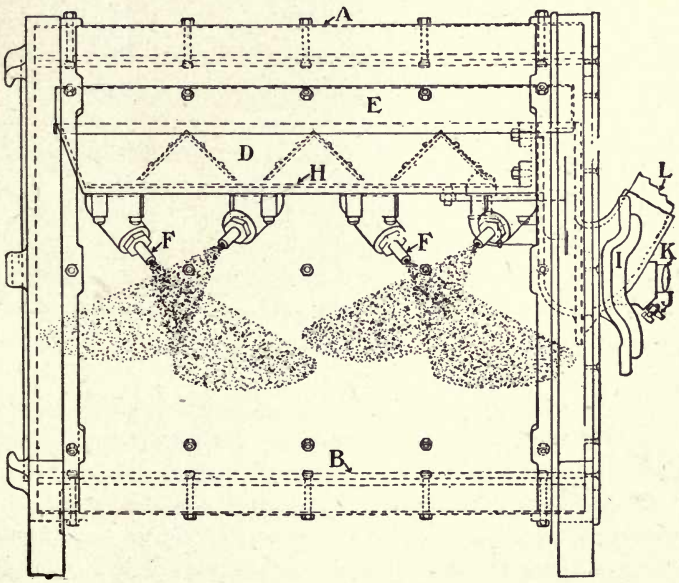

FIG. 34B—SIDE VIEW, SHOWING DETAILS OF SAND BLAST BARREL

It is always important to use a good hard, washed quality of silica sand, passing the same through an 8 or 10 mesh screen for general work. The sand must always be dry, likewise it is important that the air should be dry. In the case of a pressure or closed tank system, the very strictest attention must be paid to these particulars.

Diamond Grit and Steel Shot Used as Substitute for Sand

In many instances sand is being replaced by steel grit or chilled shot. Both have their particular field, the shot No. 5 Globe, or 16/30 Harrison, giving most excellent service in connection with the sand blast barrel. As this class of material is expensive, it must not be allowed to go to waste, good floors and tight rooms being required when used with the hose machine.

Diamond grit and steel shot have proven a very satisfactory substitute for sand, though opinions differ as to their relative value due to local conditions.

Diamond grit is angular in shape and otherwise known as crushed steel; its edges are sharp and it has all the cutting qualities of sand.

There are several advantages in using this material which are due to its slow deterioration. It does not break up like sand and, therefore, may be used many times before replacement is necessary. It is dustless in itself and naturally eliminates the dust that would otherwise be generated by the use of sand.

This material is made in a number of sizes, enabling the user to adapt a size satisfactory to the finish desired.

Steel shot carries the same general advantages as grit, though, being globular in form, its actual cutting qualities are not so severe. Its action is more of a peaning effect rather than cutting, and castings cleaned have a tendency toward a shiny appearance rather than the sand blast finish as produced by sand or grit.

Preparing the Cleaned Work for Dipping

To enable the zinc to unite with the work properly, a solution of muriatic acid and water is used. This not only serves as a flux, but removes any rust that has formed on the work in the operation of inspection. It will naturally be inferred from the above that all work should be carefully inspected to determine whether the cleaning process has been properly performed before it is subjected to the muriatic acid treatment. While the char-

acter of this muriatic acid dip may be varied, we use ordinarily a solution composed of one-half acid and one-half water, liquid measure.

Some galvanizers add 1 pound of sal ammoniac to a gallon of the mixture, but, in inour opinion, the advantage gained does not warrant the expense. Tank C, Fig. 3, is for containing this mixture.

Drying the Work

From tank C, Fig. 3, or, in other words, from the muriatic acid, the work is taken to the place provided for drying it. The position of this drying arrangement is designated E in Fig. 3. A drying arrangement for a limited amount of work may be the plates covering the fires that heat the kettle. If the work to be handled only amounts to a few hundred pounds per day, it can be dried in this way. If, however, the amount of work necessitates keeping the kettle in constant operation, a drying arrangement such as shown in Figs. 18 to 23 should be provided. Sheets and pipe should be dried in an oven.

The location of this drying arrangement is a mere matter of choice. In Fig. 3 we show it located at one end of the kettle. The castings or other work to be dried prior to galvanizing are placed, while still wet with muriatic acid, on the heavy cast iron top plates of this dryer directly over the fire box, where they are allowed to remain until thoroughly dry, when they should be passed to the end of the dryer farthest from the fire to stay until needed. If allowed to remain on the hottest part of the plate for too long a time, the work will become too hot and the acid burned off, which will necessitate re-dipping them in the muriatic acid before they can be galvanized satisfactorily. When properly dried, the salts formed by the muriatic acid should show on the surface of the work in the form of a white powder. Work that has been prepared for dipping and dried should not be allowed to get cold; and if more material has been prepared for dipping than can be finished, it should not be allowed to remain on the dried over night, but returned to the water tank. It should be remembered that rusting is merely oxidation; and freshly cleaned surfaces readily attract free oxygen from the air. While moisture assists rapid oxidation, a total immersion in water is an admirable preventative of rusting. It should, of course, be re-dipped in the muriatic solution and dried again before putting it into the galvanizing kettle.

CHAPTER VII

Hot Process of Galvanizing

Filling a New Kettle

WHEN the galvanizing kettle has been properly bricked in ready for use considerable care must be exercised in filling it with spelter to prevent the kettle from being ruined when the fires are started. In the first place, a sufficient quantity of lead should be put in the kettle to insure a depth of not less than 6 inches when molten. If the kettle is more than 30 inches deep, lead should be introduced to insure a depth of at least 8 inches. When dross forms in the process of galvanizing this lead serves as a "cushion" for it to rest upon. Lead and spelter do not mix under these conditions, the lead being of a greater specific gravity, remains at the bottom of the kettle, and no amount of stirring can cause any considerable quantity to be permanently mixed with the spelter. As a matter of fact, if lead is present in the spelter itself, as it sometimes is, most of it settles to the bottom of the kettle when the spelter becomes melted. The lead not only serves as a cushion for the zinc dross to rest upon as it forms, but greatly facilitates the removal of the dross when necessary. It is also a protection for the bottom of the kettle and keeps the spelter and dross even or slightly above the fire line, as it should be.

In filling the kettle with the slabs of spelter, place them on edge in such a way that their flat surface will lie as closely as possible to the sides of the kettle. By exercising a little ingenuity the slabs can be placed so as to practically cover the sides of the kettle. This method of packing the slabs will materially lessen the danger of burning the kettle at the first firing, as there is cold zinc against all the heated surface. These slabs should also be so arranged that, as the outside ones melt, those next to them will be forced outward against the sides of the kettle. To the inexperienced this may seem an unimportant matter, but we can assure the reader that many kettles have been ruined at the first firing through failure to give proper attention to these details.

When a galvanizing plant has an equipment of more than one kettle it is a good plan to bail molten metal from a kettle already in use into the one that is being put into operation for the first time, after the slabs have been properly arranged, and before starting the fires. Refill the kettle in operation with new metal, replacing what has thus been taken out.

Firing a New Kettle

In heating up a kettle for the first time great care should be exercised that the work is not hurried. Under no circumstances attempt to melt out a kettle for the first time in less than 36 hours. Until the spelter commences to melt the fuel should not be allowed to attain a depth of more than 12 or 15 inches in the fire boxes, and the slides that close the draft holes should be so regulated that the fires will not burn too strongly. We repeat that plenty of time should be taken to melt the metal in a new kettle the first time; otherwise, one may be put to heavy expense for replacing a burned out kettle, to say nothing of the loss resulting from over-heating the zinc. As the metal melts the depth of fuel may be increased, but it should never be more than 3 or 4 inches above the molten metal in the kettle. Of course, it is rather difficult to determine just the depth of the molten metal, but it is easy to be on the safe side even if a longer time is taken for the "melting out" operation than is actually necessary.

The Temperature of the Zinc

The question of the temperature of the zinc is the most difficult to learn; for the reason that different kinds of work demand that different temperatures be maintained. A kettle of zinc at the proper heat for wire or wire cloth would be much too hot for galvanizing castings of either gray or malleable iron, while with the metal at the proper heat or heavy work, it would be impossible to coat small work properly, even if the material was the same. Large pieces demand that the galvanizing bath be maintained at a low temperature. Small work that is strung on wires for dipping in the galvanizing bath demands a higher heat than heavy pieces. Work that is galvanized in baskets often requires a still higher heat than work that is strung on wires, as hereafter described.

We shall give the degrees of heat that a pyrometer should indicate when different kinds of work are being done, basing the rules

given on the supposition that when the metal is barely melted—that is, at a temperature that would just keep it in a liquid state, the pyrometer indicates 750 degrees of heat. We shall also give the best rules possible for determining the proper temperature by the appearance of the metal and by other signs.

Large gray iron castings require that the metal be at the lowest temperature possible and still have it liquid. At about this temperature it will be silver white in color, will burn sal ammoniac slowly when thrown on its surface, and when a skimmer is passed over its surface the oxide will be slow in appearing. With the metal in this condition the pyrometer should indicate about 800 degrees of heat. This temperature is also suitable for galvanizing very thin castings that are intended to be "spangled" or to have a crystallized appearance—for example, sinks and like work.

For work that is drawn through the clear metal the pyrometer should indicate not less than 850 degrees. At this temperature the metal should have a slightly bluish cast, burn sal ammoniac moderately quick and show the oxide in a few seconds after the skimmer has been passed over its surface. This temperature is about right for galvanizing wrought iron pipe, the cheaper grades of sheet iron and goods made from it, such as coal hods, ash cans and chamber pails. Heavy malleable iron castings will also coat nicely at this heat.

For small work, such as nails, and in fact, almost any work that is done in baskets or strung on wires and drawn through flux, the pyrometer should indicate not less than 900 and not more than 925 degrees F. The metal at this heat should burn sal ammoniac quickly and oxidize quickly, and will be quite blue in color. This temperature is about right for sheet steel and articles made from it, as well as steel pipe.

We wish to impress upon the reader that these rules for temperature are based on the supposition that the galvanizing bath is composed of strictly Prime Western Spelter that has not been subjected to overheating, and that the bath is practically fresh by reason of recent starting or recent drossing and re-filling with new metal. If "Remelt" spelter is used exclusively, or even partially, the proper degrees of heat can only be determined by observation and experience. Therefore, we repeat that no hard and fast rules for operating the bath exclusively by the pyrometer can be given.

Dipping the Work in the Molten Zinc

We will describe the manner of handling several different articles as a general guide for dipping all kinds of work. Considerable skill is required to bring work out of the molten metal and cool it in such a manner that the surface will be smooth, free from blisters and without lumps of surplus metal attached.

Before commencing to dip the work, cover part of the surface of the molten zinc with a sal ammoniac flux to keep the oxidized metal from adhering to the material. To prepare this flux, sprinkle a few handfuls of sal ammoniac on the surface of the bath, and as soon as it is melted add a few drops of glycerine. This will cause the flux to thicken somewhat and will prevent it, in a measure, from covering the entire surface of the metal. The glycerine also causes the flux to remain stationary, so that when the operator is ready to draw work from the bath the flux will not cover the space he has cleared with his skimmer for so doing. The tool designated E in Fig. 25 is a skimmer used for clearing the surface of the metal before drawing work from the bath.

The flux not only prevents the zinc from oxidizing, but also assists the metal in adhering quickly and evenly to the work. Keep the flux fresh by adding more sal ammoniac from time to time as required.

We will suppose an article to be dipped is a cast iron sink or some similar thin casting, in which case have the metal at the temperature first described under the heading "The Temperature of the Zinc." After satisfying himself that the casting has been heated until it is perfectly dry, the operator catches the article with a pair of tongs and plunges or drops it as quickly as possible, without causing the metal to spatter, through the flux into the molten zinc. He must keep the article beneath the surface until it becomes as hot as the zinc itself. After the article has been in the bath a few minutes it should be rinsed or washed around in the metal in such a way that the flux will come in contact with all parts of it. When the article is thoroughly coated clear a space on the surface of the molten zinc with the skimmer, sprinkle on a little dry white sal ammoniac, and draw the article slowly from the metal.

In performing this operation catch the article with the tongs in such a way that the part they grasp will be the last to leave

the zinc. Do not lift the article clear of the metal with the tongs you use in the bath, but provide a second pair to complete its removal and to handle it until cooled. Hold the article in such a position as to cause the surplus metal to flow to one point, and just as the drop starts to harden remove it with a stiff brush or an old file. Expose the article to the air until crystals appear, and then brush it lightly with a brush wet in clear water. Do not dip the article in water, especially if it is a very thin casting, as that would be quite likely to break it, and the coating would not be as bright as if left to cool gradually after brushing with the wet brush. Thick, heavy castings may be dipped in water at once on removing them from the molten metal.

Coal hods and similar goods of sheet steel or iron only need be left in the bath a few seconds. The flux through which they pass should be confined at one end of the kettle by a piece of sheet iron long enough to go across the kettle from side to side. This is called a "flux guard," and it should enter the metal about 2 inches, with the upper edge as high or a little higher than the sides of the kettle. In galvanizing sheet metal ware the flux should be made to foam up nearly to the top of the kettle by using glycerine. The goods should be passed through the flux under the guard to the end of the kettle that is kept clean. In passing the article under the flux guard, keep the opening up so that none of the flux will be carried along with it. Remove the article from the metal in the way described for sinks and similar articles, but do not sprinkle the clear surface of the zinc with sal ammoniac. Allow the work to cool in the air. If any particles of flux have adhered to the work while drawing it from the molten metal, remove them with a wet brush while the article is still hot.

Some articles can be galvanized to best advantage by stringing them on stout wires about 2 feet long. When this method is employed, string on a number of the pieces and then bring both ends of the wire together and clinch them securely. For suspending work in the metal which is strung this way, use a hook, shaped in the form shown by Fig. 25 and designated G. Provide several of these hooks, so that a batch may always be ready for removal from the kettle when the previous one has been removed. A piece of $\frac{3}{8}$-inch round iron, bent in the shape of the letter S, may be used to remove the strings of castings from the hooks, and also for handling them until they are cooled. The wires C and D, Fig. 25,

are also intended for stringing small articles for the purpose of dipping them in the molten metal.

In handling small articles on any of these wires after they are drawn from the metal, use a shaking motion that will free them of surplus metal, and also prevent their sticking to each other when plunged in the water. Some practice will be necessary before this can be done properly.

It is a good plan to warm the cooling water slightly for cooling some articles, and to have a thin film of oil on the surface. Small articles strung on wires may be drawn from the clear metal after sprinkling on a small quantity of powdered sal ammoniac, or may be drawn through a clean, thin flux of sal ammoniac, to which a few extra drops of glycerine have been added. If the latter method is used, as it should be if the articles are such as are liable to rub and stick together, oil should not be used on the cooling water.

Small work that cannot be strung on wires may be galvanized in a wire or sheet iron basket. We have already described these, and they are designated in Fig. 25 as A and B.

When baskets are employed, the flux should be of such consistency that it will flow freely among the work. A block of iron should be placed on the brickwork beside the kettle in such a position that the operator can rest the handle of his basket across the block with the basket hanging over the kettle. Using this block as a rest, the operator should shake the basket up and down sharply for several seconds after it has been drawn from the bath to free the work of surplus metal, and when this is accomplished he should dump them into the water to cool, after which, dry them off by dipping in boiling water and throwing them into dry sawdust. Nails or tacks may be shaken out of the basket onto an iron plate, placed at an angle, over a tub of water to separate them. The plate should be inclined sufficiently for the work to slide into the water readily.

Considerable difficulty is experienced in removing the surplus zinc from small articles, such as nails, tacks, bolts, nuts, washers, rivets, screw eyes, screws and sheet metal or wire specialties when hot galvanizing them unless mechanical means for accomplishing this purpose can be employed. This fact has been responsible for the invention of several different machines and devices intended to remove the surplus metal after the articles have been taken from the molten zinc. Notable among these is the "Porter Ma-

chine," which, according to the inventor, will handle anything from a small tack to a 60-penny nail at the rate of from 2000 to 3000 pounds per hour. This machine removes all unnecessary surplus metal by means of beaters or fans, cools the articles without their coming into contact with water, and automatically delivers them into kegs or boxes ready for shipment. As this machine occupies considerable space and has a large capacity it is best adapted to the large producer and has been used by such concerns for some time past. Another means of accomplishing the same result is found in the "Watrous Machine," which utilizes the action of centrifugal force for throwing off the surplus metal while it is still molten. This machine is claimed by the inventor to have been in successful operation for some time by several manufacturers.

Various other machines designed for the same purpose are claimed by their enthusiastic inventors to attain remarkable results, but the prospective purchaser of any such device or machine should thoroughly investigate the matter before making a decision, as any of them may have limitations or objectionable features which can best be learned from some one other than the inventor who has had actual experience with the device. Removing surplus zinc is not always the only consideration when galvanizing small articles, though many inventors seem to lose sight of the fact. For this reason, the cost of production (when considering the merits of a machine or process) should always be given considerable attention, and cost figures, obtained under actual working conditions and not made in round figures from estimates or unconfirmed reports, should be secured for careful consideration.

CHAPTER VIII

Galvanizing Sheets

SHEET iron, wire, wire cloth and poultry netting are galvanized by being passed through the zincing bath mechanically, and as the mechanical means employed are so varied and complicated we shall not attempt to illustrate them. The galvanizing of these materials is carried on principally by large manufacturers who produce the finished article from the raw material, and the galvanizing is simply one process of manufacture.

As a brief description of galvanizing sheets by hand may be useful to some, we will describe the old hand method in use before the introduction of mechanical methods.

The hand galvanizing of sheet iron requires the use of a kettle long enough to accommodate the sheet and deep enough to permit of its being dipped in the bath without interfering with the dross in the bottom of the kettle; consequently, a kettle for sheets must of necessity be not less than 8 feet 6 inches long by 4 feet deep, and it should not be less than 18 inches in width, and a better width is 2 feet. As it is necessary to pass the sheet into the molten metal through a flux of sal ammoniac what is known as a "flux guard" is employed. This flux guard should be made of T-iron, to which an iron plate can be riveted so that when the arrangement is placed in the bath the guard effects a longitudinal division of the metal. This flux guard should be wide enough to go under the metal 2 or 3 inches when the metal is at its lowest working height. After a sheet has become thoroughly coated it is pushed to the side of the kettle that has not been covered with a sal ammoniac flux and withdrawn from the metal with the aid of properly shaped tongs attached to a light single block and fall. If the pickling and inspection of the sheet has been properly done the coating takes place without the usual rinsing or washing through the sal ammoniac flux floating on the surface of the molten bath; but unless this has been properly done, it will be necessary to wash the sheet through the flux until a perfect coating has been obtained.

In the hand dipping method of galvanizing sheets, a simple arrangement was used that permitted the operator to transfer the sheet from the side of the kettle where it entered the bath to the opposite side where it was withdrawn, and also permitted the edge of the sheet being lifted, semi-automatically, just high enough out of the metal to permit of its being readily seized with the tongs used for withdrawing it from the bath. It was the practice in some plants to allow the coated sheet to form crystals by cooling in the air, after which the sheet was plunged into a bath of cold water and dried off in sawdust. When it was desired to have a bright plate without the crystals the sheet was plunged into the water immediately after it had been drawn from the molten metal. This prevented the formation of crystals and, as stated, produced what was known as bright galvanized sheets.

Among the old English galvanizers it was the practice to carry a clean flux of sal ammoniac on the opposite side of the flux guard from which the sheet entered. This prevented oxidation and was the means of producing a somewhat thinner coating. It was also the practice of some operators to cover the metal on the side of the flux guard from which the sheet was drawn with foundry sand or coke dust.

Mr. James Davies, an English authority on galvanizing sheets, describes in his book, entitled "Galvanized Iron, Its Manufacture and Uses," a very practicable and simple mechanical device for the galvanizing of sheets. His device consists of a strong square iron frame in which two rollers work. The rolls are made of hammered forgings and turned. He gives the usual size as 3 feet 6 inches long by 9 or 10 inches diameter. The frame and rolls are suspended from bars placed in the bath at such a depth that the rolls are completely immersed in the metal, with the center of the rolls from 14 to 15 inches below the surface. The rolls have a hammered wrought iron pinion on the end of one and two wrought iron pinions at the other end, and are driven by another wrought iron cog wheel. The driving shaft should have a four-cone pulley with a corresponding cone pulley overhead for varying the speed according to the thickness of the sheets, as a thin sheet takes less time to coat than a thick one. With this arrangement what is known as a flux box is placed on the entrance side of the bath and one on the exit side of the bath. From these flux boxes guides are arranged which are removed when the day's

work is finished. The sheet goes into the flux box in the wet state and as it emerges from the flux box on the other side it is seized by the operator with a pair of self-acting tongs which are attached to a rope running over a pulley. The action of the rolls in the bath keep up a constant circulation of the metal, which, in a measure, prevents the dross from solidifying.

In addition to this comparatively simple method of galvanizing sheets automatically, we have what is known as the "Heathfield's Patent Process," the advantages of which are best described in the patentee's own language, which is, in part, as follows:

"One man and one boy are sufficient to run the machine, and their combined labor will turn out far more galvanized sheets per day than a much larger number of men can do by any other process.

"The machine will turn out with sufficient labor 12 tons or more of galvanized sheets assorted, 14 to 30 gauge or thinner, per turn of 10½ hours, and with a good dipper will sometimes do as much as 11 or 12 tons per turn of sheets assorted 26 to 30 gauge; while 8 English tons is a very moderate average in a turn of 10½ hours for sheets of these latter thicknesses.

"The machine will do any thickness from 14 to 30 gauge or thinner, any width up to 4 feet (or wider if a large enough machine is supplied) and any required length.

"As the pot is only 2 feet 8 inches deep, and holds only about 12 tons of spelter (zinc), the very large output, compared to the quantity of spelter in a molten state, reduces the dross made per ton of sheet below that made by any other plan; the pot, of course, being pushed to its maximum, and worked night and day.

"No oxide is made while the machine is at work.

"The quantity of muriate of ammonia used per ton of sheets is very small. Fourteen pounds, or less, will suffice to galvanize one ton of sheets, 28 gauge thick, while stronger sheets take proportionately less.

"The coke bill is small. If the pot is kept fully at work, six tons of ordinary gas coke of fair quality will keep the pot at work a week, including firing it on Sundays.

"The quantity of spelter used per ton of galvanized sheets made is greatly reduced, while the appearance of the sheets is much improved, and they leave the machine ready for use, without any subsequent brushing, washing or drying.

"The following are the approximate quantities of spelter deposited on the sheets, in the manufacture of one ton of galvanized iron by the Heathfield patent machine; the various gauges being calculated at the number of galvanized sheets per ton, which it is usual to supply in England:

16	18	20	24	26	28	30 gauge
120	140	195	245	325	350	420 pounds

"In the very light gauges it is possible to use sheets a gauge stronger than can be used in the ordinary process, and yet produce the same number of galvanized sheets per ton as is customary by the old plan.

"This saves considerably the cost of black sheets on 28, 29 and 30 gauge galvanized."

In addition to the Heathfield process we have the Bayliss patent process. The patentee makes the following claims for his process:

"The patentee claims that this method dispenses with a considerable amount of manual labor. The patentee passes the sheets, after being pickled, through a pair of cold rolls upon which a stream of water is continually flowing. The object of this is to impart a fine smooth surface to the sheets which have been roughened by the pickling process. From the cold rolls the sheet passes onwards towards the bath which it enters through a pair of rolls fixed on the brickwork of the galvanizing bath. It then passes through a guide fixed below the surface of the metal, and finally emerges through a layer of sand on the surface. The sheet is then seized by a pair of rolls having studs inserted at intervals which meet and grip the sheet. The sheet then passes on by means of an endless chain band to a set of revolving brushes which brush off any adhering particles of sand."

CHAPTER IX

Galvanizing Wire, Netting and Tubes

WIRE, wire cloth and poultry netting are galvanized practically automatically. In galvanizing wire cloth and poultry netting it is necessary to divide the molten metal longitudinally with a flux guard of the character described for galvanizing sheets. The side of the bath where the material enters should be covered with a heavy flux or sal ammoniac, and the side where it leaves the metal should be covered with coke dust to a

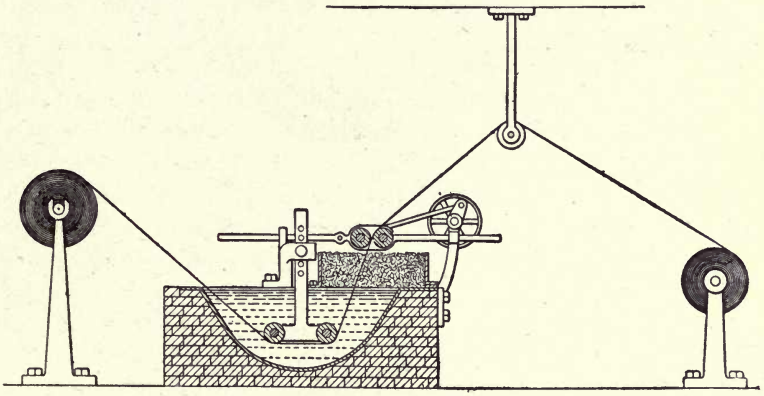

FIG. 35—AUTOMATIC WIRE GALVANIZING MACHINE

depth of several inches. The coke dust must be constantly sprinkled with water while the material is passing through it. The best means to accomplish this is to have a perforated water pipe of the required size constantly discharging water in sufficient quantities to keep the coke dust on the surface of the metal well moistened. The operation of drawing the work through the molten metal is performed by a revolving drum so constructed as to permit of the ready removal of the roll of wire cloth or poultry netting after it is galvanized. Where wire is being galvanized, several strands are passed through simultaneously, and the speed varies according to the gauge of wire being handled.

A description of a device that is claimed to be an improvement

for galvanizing wire cloth recently appeared in *The Brass World,* as follows, and it is illustrated by Fig. 35.

An Improvement in Galvanizing Wire Cloth

"An improvement in galvanizing wire cloth has been patented by George M. Wright. The cloth is drawn from a reel down through the bath of molten zinc, contained in an iron kettle. At the bottom of the kettle are roller guides, as shown in the illustration. The cloth then passes through a mass of charcoal 9. At the same time a lateral motion is given the cloth by a device shown. The charcoal removes the surplus zinc from the top and sides of the wires of the cloth, but on the bottom of the meshes it fails to brush it off. By giving the cloth a lateral motion, however, this surplus zinc on the bottom of the mesh wires is scraped off."

The Influence of Galvanizing on the Strength of Wire

As there are enormous quantities of galvanized wire used, the effect of hot galvanizing on the strength of wire may be of interest to some, and we cite the following from *The Iron Age.*

"At the International Congress of Metallurgy, held at Dusseldorf recently, Dr. Heinrich Winter of Bochum read an elaborate paper on the above subject. Particularly in mine installations is it important to protect the hoisting ropes by a suitable rustproof covering. Coating with zinc has been found to answer the purpose admirably, for the protection afforded depends upon the formation of a couplet in which the zinc of the galvanized iron forms the electro positive element and the iron the electro negative, when the material is immersed in water or other fluids. The zinc takes up oxygen, gradually forming a zinc oxide, while on account of the evolution of hydrogen the iron remains inert even if the continuity of the zinc coating is slightly broken.

"In the process of hot galvanizing there is no question, however, but that the strength and particularly the resistance to bending and torsion are considerably affected, and the purpose of the paper in question was to determine the degree of this action. Many theories are given regarding the loss of tensile strength. Poor material is cited, but tests have shown that even the best of material suffers loss. Again, the steel is supposed to have been 'overdrawn,' but microscopic tests do not show signs of this in materials losing 28 per cent. of resistance to torsion effects. Finally,

irregularity in the coating of zinc is supposed to change the resistance to torsion, by obstructing the power applied, in varying degree in the test piece. This also will not explain the situation, for many wires with uneven coats of zinc showed practically no deterioration in this regard.

How Tests Were Made

"To study the matter carefully, the first thing was to note whatever changes might be produced by the drawing down of the billet to wire. Twelve test pieces were therefore cut from the material from the original billet down to the actual wire, pickled and galvanized, but not annealed. These sections represented the various stages through which the material went, and were etched by immersion in a copper-ammonium-chloride solution (1:12) for one minute each, the copper deposited being carefully wiped off with absorbent cotton while under water. The lighter outer zone as distinguished from the darker inner zone, showing segregation, could be followed plainly through the whole series made from this billet. Further etching with an alcoholic solution of picric acid (1:25) for 15 minutes indicated that the grain of the inner higher phosphorus zone was larger than the outer one with lower phosphorus. The results of the physical tests on the material showed the usual phenomena, an increased ultimate strength, with brittleness to a point to almost wipe out the power to twist it in the final wire before further heat treatment.

"In order to not disturb the zinc layer in making sections for polishing, the wire was first cleaned carefully with alcohol and ether, placed in a solution of copper potassium cyanide, and a weak current applied to coat it with copper. It was then washed with alcohol and ether, and finally melted into Rose's alloy, which on account of its low melting point gave a perfect protection for the galvanizing coat, and yet did not alter the microstructure of the material. Finishing up the polished sections with a very little rouge on parchment paper with a 2 per cent. solution of ammonium nitrate for five minutes, thus etching them, gave excellent results. With 125 diameters enlargement the makeup of the section is plainly shown. A dark band for the zinc, light for copper and black for the Rose metal, with lighter color for the steel. A separate band may be distinguished between the iron and the zinc coat.

Absorbed Hydrogen Gas Does Damage

"This material, it should be remembered, was pickled before galvanizing. Hence many investigators brought back the brittleness of galvanized steels to an absorbed hydrogen from the acid bath. This absorbed gas can, therefore, do considerable damage. Further investigations, however, have shown that heating the steel up to 250 degrees F. for four hours removes this effect entirely. Hence, inasmuch as the microscope does not show any indications of an iron hydroxide either there remains only the theory that between the zinc and the iron there is a layer of an iron-zinc alloy, formed either because the wire was left in the zinc bath too long in contact with the zinc, or that the bath was too highly overheated. That such an alloy exists is well known, every galvanizer being worried by large amounts of 'dross,' which contains 3 to 5 per cent. iron, and is a very brittle material. On the other hand, in order to get the zinc coat to stick to the iron, it is necessary that such an alloy be made with the iron, the composition varying from high zinc at the contact to no zinc a little distance into the iron, as was clearly shown by Sherard Cowper-Coles.

"A study of the structure of the material before galvanizing shows that where this is large grained and easily to be penetrated, much zinc gets in. Even where the microscope does not show the layer of the zinc-iron alloy, it is undoubtedly there as a very fine one, and depending upon the extent of this layer will be found the phenomenon of loss in power to bend and twist when taken in connection with the change in structure through the heat treatment. It is well known that with soft steels the elasticity is changed with temperatures as low as 750 degrees F., but it also takes some time to do this. Hard drawn steel would consequently become softer by remaining in the bath longer, but this gain will quickly be offset by the formation of a heavier layer of iron-zinc alloy.

"The conclusion of the paper is that the wire industry is perfectly capable of furnishing galvanized wire which has not suffered seriously as to its physical properties, this being a question of proper practice in regard to removal of damage done by pickling, and proper bath temperature and time of the wire remaining in it. It is, therefore, necessary to treat the wire before galvanizing to remove the hydrogen absorbed and to regulate the temperature of the zinc bath between close limits. The latter is not easy, as

there are difficulties in pyrometry and also in the proper firing where many wires are passed through constantly with consequent irregular lowering of the temperature."

The Automatic Galvanizing of Tubes

Iron and steel pipe and tubes are hot galvanized in large quantities annually, and large tube manufacturers have, of course, adopted mechanical means as far as possible for handling their product through the galvanizing process. Many ingenious devices have been invented and many of them are patented. Such a device was illustrated and described in *The Iron Age* recently as follows:

"An arrangement that has been in successful operation for the last three years at Laurahütte, Upper Silesia, for the hot galvanizing of tubes, is described by Engineer G. Buchert of Laurahütte. Fig. 36 shows the details. The tube *a* is drawn out at one end of the zinc bath *b* and passed through the arrangement *c* for removing the excess spelter from the outside and smoothing the surface. It is gripped in tongs attached to a specially built transverse piece and by means of the two endless chains *d* is carried up the incline *e* and along the upper track *f*. After the lower end of the tube has passed through the cleaning arrangement it falls on the cleaning grate *g*, and automatically cleans itself by striking against the bars of the grate, so that all the excess spelter on the inside of the tube falls down and collects in the space *h* underneath the grate.

"After the tube has reached the end of the grate it comes on to the inclined bench *l*. The position of this bench when at rest is horizontal, slightly higher than the water bosh *m*. (See end view.) The falling of the bench to the inclined position is brought about by the wire cable *n*. This is fastened to the traveling piece *o*, which is carried along the upper track by the tongs (holding the tube) to the automatic release *p*. The moment the tongs are opened the bench *l* carrying the tube takes its original horizontal position. By means of levers, the bench is inclined and the tube rolls of itself into the water bosh *m*. It is raised from here by the revolving shaft *q* with its star-like arms *r*, and rolls down the skids into a car, properly galvanized and cooled. The tongs and cross piece fall down the incline *s* on a traveling belt *t*, and are carried back to the starting place, where a new tube is taken, gripped and started on its way by hand.

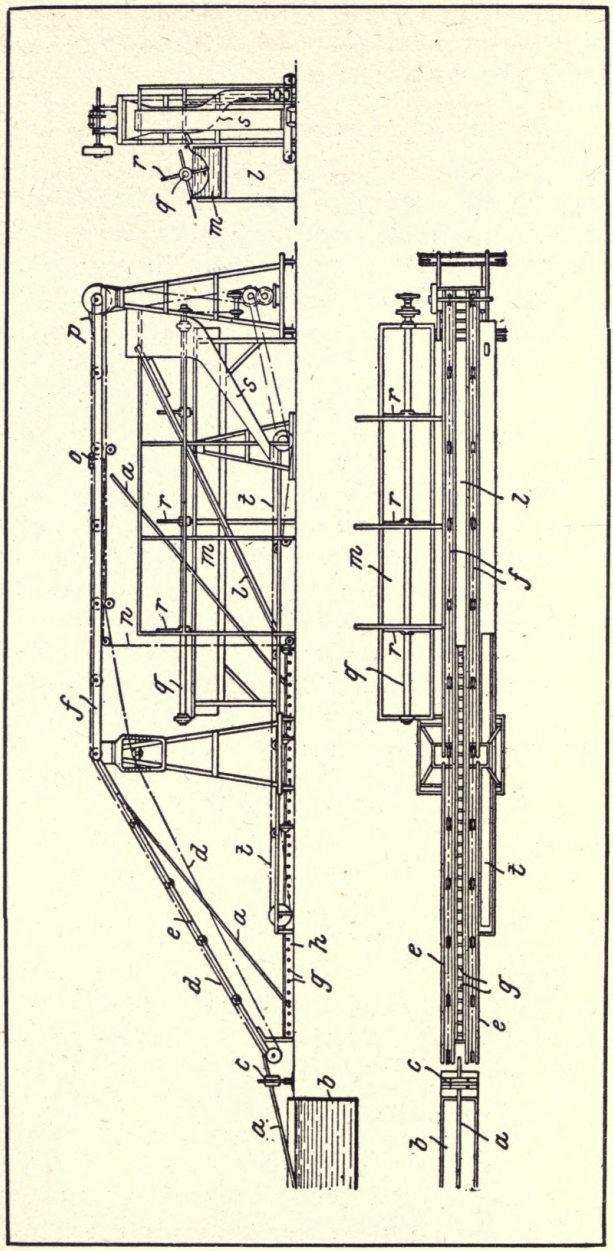

FIG. 36—PLAN AND ELEVATION OF ARRANGEMENT FOR GALVANIZING TUBES

"As compared with hand galvanizing, the apparatus has shown a saving in wages of 33⅓ per cent. and in spelter of 0.8 per cent. of the total weight of tubes to be treated. Under German conditions this amounts to $1.48 per metric ton of finished tubes. A special crane for holding and agitating the tubes during pickling is also briefly described, which has proved very successful."

CHAPTER X

By-Products of the Hot Galvanizing Process

THREE by-products are produced in the process of hot galvanizing. They are known by the trade terms of "Hard Zinc Dross," "Sal Ammoniac Skimmings" and "Zinc Ashes," sometimes called "Dry Zinc Skimmings," and a brief description of each is given in order.

These materials are bought by all the principal scrap metal dealers, who, as a rule, can be depended upon for fair business dealings. There are exceptions, however, and for this reason sellers should never dispose of galvanizing by-products by sample, nor allow the word sample, or reference to any particular grade of quality, to be used in the terms of sale. The buyer may be permitted to take samples of the materials from the bulk as he chooses, but only at his own risk. Each lot should be sold on its merits as it stands without any representations as to quality and absolutely without recourse, except in the matter of weights, which, of course, should be as unquestionably accurate as possible. We have learned through experience that failure to take these precautions may lead to a great deal of trouble and expense.

Prices vary with the price of Prime Western Spelter, and the quotations made are usually based on the price of this metal, and the terms of payment in the sale of these materials are nearly always cash.

Workmen cannot be too careful in the removal of by-products from the galvanizing bath, as every pound of good zinc removed unnecessarily represents a direct loss, and it is a fact that galvanizing employees as a rule are inclined to be careless with and slow to appreciate the value of materials which they use. By-products are valuable, and should be treated and stored accordingly. It is economy to place a thoroughly competent and conscientious man in charge of a galvanizing plant even at what might seem a high price. The man who is satisfied with the smallest salary is not necessarily the cheapest man, and the fact should not be lost sight of that a few dollars saved on the pay-roll may

easily be more than offset by losses due to incompetency and wasteful carelessness of a foreman or those working under him.

The question often arises as to whether it is advisable for the individual galvanizer to attempt the recovery of his own by-products. The reclaiming and utilization of these so-called waste products has received the attention of scientific men in recent years, and as previously stated, have, through scientific investigations and experiments, been made to yield high values.

Commercially practical methods for the economical treatment and use of drosses and skimmings on a large scale have been developed with the result that galvanizers can now secure high prices for materials which were formerly consigned to the dump as waste products, and it is doubtful if they can realize as great returns by the treatment of their own by-products as by selling them at prevailing prices to the large buyers who make a specialty of handling these materials.

Zinc Dross

Zinc in a molten state will alloy with iron so that iron submerged in it will begin to dissolve as soon as it becomes as hot as the zinc bath. The addition of only a small percentage (as little as 3 or 4%) of iron to the bath will form an alloy of zinc and iron called zinc dross, that is of greater specific gravity than zinc itself.

This dross in galvanizing is formed principally by the continued washing away of the articles which are being galvanized, although a considerable amount is formed by the action of the zinc on the inside of the kettle, as evidenced by the gradual eating away of galvanizing kettles from the inside until they are eaten completely through, necessitating the installation of a new kettle, and if by accident or design the kettle is run at a high heat, dross will form very fast. As the dross forms it settles to the bottom of the kettle and becomes hard. When the accumulation has reached a point where it interferes with the work it must be removed. This is easily done with the use of a proper tool made for that purpose and called a dross scoop. The handle of the scoop should be about twice the length of the kettle unless the kettle is of a size requiring the use of tackle in drossing it. The scoop should be well perforated with holes not less than $\frac{1}{2}$" in diameter to allow the clear metal to flow back into the kettle, and

care should be taken to keep these perforations always open and unobstructed.

Before commencing to dross the kettle, i.e., to remove the dross, skim all the flux from the surface of the metal with a perforated skimmer, and if it is in good condition save it for future use. If this flux is broken up when cold and placed carefully back on the surface of the zinc it will soon melt to its former consistency. A perforated skimmer for removing sal ammoniac flux and zinc ashes is shown in Fig. 25 and is designated F.

When drossing do not stir or roll the bath unnecessarily in forcing the scoop into the hardened mass. Force the scoop gently into the dross and when satisfied that it is full raise it out of the metal by resting the handle on the end of the kettle to get a leverage. Let the scoop remain supported on a bar over the kettle until all the liquid metal has drained back. Dross hardens very rapidly when exposed to the air, and no more time than necessary to allow as much good metal as possible to drip back into the kettle should be consumed before getting the dross into the dross pans. If the handle of the scoop is jarred by blows from a hammer or bar of iron more of the clear metal will separate from the dross than if this was not done, and the mass of dross will also drain much more freely if cut down through several times with a flat iron shovel. As soon as clear metal ceases to drip, dump the dross while still in a semi-fluid state into cast iron pans or molds made for the purpose and about 2″ deep, 15″ long and 9″ wide inside. The dross, while still hot, should be worked or molded into the pans and smoothed off on top with a shovel. When the dross hardens in the molds dump them and you have the commercial Hard Zinc Dross.

If there should be a large amount of dross in the kettle at a time when it is desired to allow the fires to go completely out it should be removed. If allowed to cool with a large amount of dross lying in the bottom the result will most likely be a burst kettle.

The loss caused by the formation of dross is quite large even with an experienced man in charge of a kettle, but the amount of dross made is greatly increased by failure in keeping the metal at a temperature which will not injure it; also by allowing work to be lost in the kettle or by immersing work in the bath that has not been properly prepared.

Running Over or "Sweating" Zinc Dross

We are often asked whether it will pay the small galvanizer to try to recover the good zinc from his dross, and if so, how best to accomplish the desired results. It formerly was the practice of most concerns doing galvanizing to run over, or, as it is termed, "sweat" their dross, but conditions which formerly made this profitable have changed materially in the last few years. At the time of the first issue of "Galvanizing and Tinning" the very best zinc dross could be bought at from 25 to 35% of the price of spelter. To-day the most inferior grades readily bring from 50 to 60%, and some of the better grades as high as 80% of the price of the best quality of zinc.

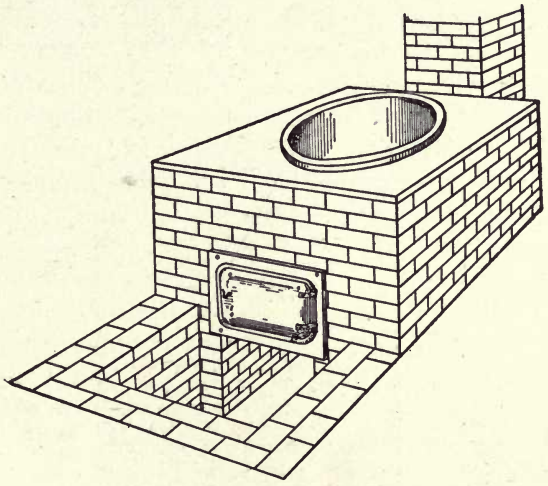

FIG. 37—DROSS SWEATING FURNACE

Without entering into any further discussion regarding the advisability of attempting the recovery of zinc dross, we reproduce the illustrations of apparatus for "sweating" dross that appeared in the first issue of "Galvanizing and Tinning." In Fig. 37 we give a perspective view of the kettle and brick work. Fig. 38 is a top view. Fig. 39 is a vertical section of Fig. 38 at A A, and Fig. 40 is a horizontal section of Fig. 39 at the grate line B B. The kettle and casting details for bricking in are shown in Fig. 41. This arrangement is so simple that we do not think it necessary to describe it in detail.

A kettle 30″ in diameter and 20″ deep will answer the purpose very well, and should be made of cast iron, with bottom about 1½″ thick.

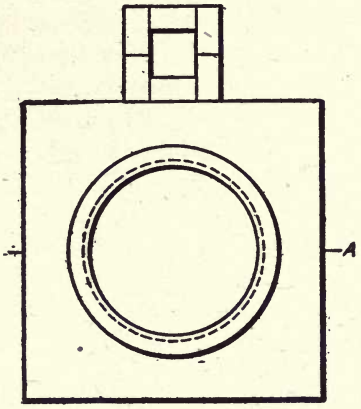

FIG. 38—PLAN OF FURNACE

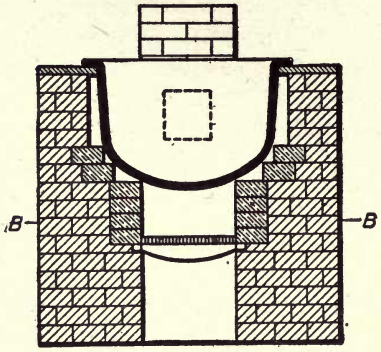

FIG. 39—VERTICAL SECTION OF FURNACE AT A-A FIG. 38

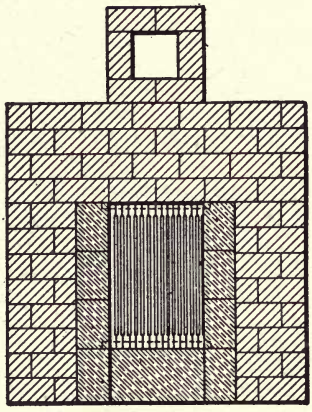

FIG. 40—PLAN OF FURNACE AT GRATE LINE

To separate the good metal from the dross, first melt up about 6 or 8 inches of lead in the bottom of the kettle and then put in the dross. Bring the dross to a temperature that will cause it to have rather a dark blue color, or to a point where the pyrometer will register about 1050 degrees. When this is accomplished stir the mass with a long-handled ladle for about one-half hour, and then allow it to settle. When the mass has settled the lead will

be at the bottom, the dross will lie on the lead and the clear metal will be at the top, where it can be bailed out into pans. The stirring may be repeated once or twice after each bailing operation. After all the clear metal available has been extracted, remove the dross and put it into pans or molds as when first taken from the galvanizing kettle.

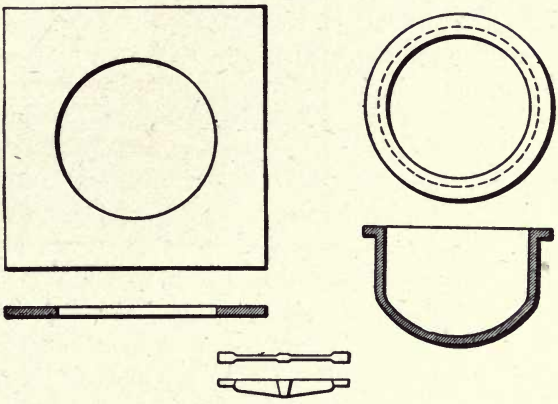

FIG. 41—CASTINGS FOR DROSS SWEATING FURNACE

Sal Ammoniac Skimmings

This is the trade term for the sal ammoniac flux used on the top of the galvanizing kettle when its usefulness as such has passed. The thick dirty portion of the flux must be removed from time to time as necessary and should be placed in sheet iron pans of convenient size to cool, when it will be the commercial Sal Ammoniac Skimmings, and should be stored in a dry place. In a plant operated for small castings, forgings and similar work this skimming is usually done twice daily, once the first thing in the morning and once before starting in the afternoon.

Too much care cannot be used in skimming the spent flux from the galvanizing bath, as a considerable amount of zinc can be carried off in the flux by carelessness without its being noticed or suspected, and may be the means of quite a loss. A perforated skimmer, shown in Fig. 25 and designated F. should always be used, and it should be kept clean. The perforations should be sufficiently large to permit free exit of metal, about ¼″ diameter, and the handle of the skimmer should be tapped on the edge of the

kettle while filled with hot flux to shake out as much of the free metal as possible.

Sal Ammoniac Skimmings should never be mixed with Zinc Ashes, as the value of both will be considerably reduced by so doing. Each should be skimmed from the bath into a separate receptacle, stored separately and plainly marked when packed for shipment.

While several methods of treatment for reclaiming the wastes of Sal Ammoniac Skimmings have been developed, we do not consider it economical for the individual galvanizer to attempt their recovery on a necessarily small scale for reasons previously stated. In a plant having several kettles in operation considerable zinc can be recovered from Sal Ammoniac Skimmings with little expense by remelting them in a large mass. This can best be done after drossing when the surface of the zinc is low down in the kettle. Put several days' accumulation of skimmings, which have been kept in a dry place, into the kettle at once, which, when melted, should be several inches deep on the top of the metal. Stir this mass well with a poker or skimmer and then skim it off into flux pans, taking first the lighter top portions, and being careful to dip the skimmer through into the molten zinc no more than necessary.

Large lots of Sal Ammonic Skimmings are often shipped loose in bulk, while small consignments are usually forwarded in casks or barrels.

Zinc Ashes

The name Zinc Ashes is the trade term for what is really zinc oxide, and which in the galvanizing process accumulates on the bare surface of the molten zinc. Zinc Ashes are formed by continually skimming the surface of the bath clean for the withdrawal of work and by the melting up of new spelter after drossing. It also collects when the bath is lying idle if it is in a molten state, as on Sundays and holidays.

Before removing Zinc Ashes from the kettle a little white sal ammoniac should be sprinkled over and well stirred into them with a poker or skimmer. This will be found of great assistance in reducing the particles of metallic zinc to a molten state.

Plenty of time and care should be used in skimming, as small drops of zinc remaining suspended in the hot ashes are very hard to shake out, and carelessness will greatly increase the losses.

It is good practice to screen Zinc Ashes through a No. 6 or No. 8 mesh riddle, either by hand or machine, before packing them for the market, throwing out all foreign material. A surprising amount of zinc can be recovered in this way, which can be easily remelted in the galvanizing bath.

Any attempt at reclaiming the fine ashes does not pay, as the reduction of zinc oxide is not at present commercially practical for the small operator. These ashes or oxides are largely used by paint manufacturers, however, and they find a ready sale in the scrap metal market.

Zinc ashes are usually packed for shipment in bags or barrels, and should always be stored in a dry place.

CHAPTER XI

Replacing Old Galvanizing Kettles

GALVANIZING kettles are good for service until they begin to leak badly or have become so warped or distorted that they cannot be operated satisfactorily. The life of a kettle ranges from a few days or weeks to several years, depending on the class of work handled, and whether it has had careful and intelligent operation. Comparatively new kettles sometimes develop a leak through some defect in the steel sheet from which they are made. If such kettles are in good condition otherwise it may pay to bail the molten zinc out to a point below the leak and repair it, either by rivetting on a patch or by welding with electricity, oxy acetylene gas or other method that seems most advisable or economical.

If an old kettle which seems to be generally thin and worn starts to leak it is usually economy to tear it out and replace at once with a new one. If a successful attempt is made to stop a leak in an old kettle of this kind it will more than likely start to leak in other places within a very short time and your trouble and expense will be of little avail.

When a kettle, whether old or new, starts to leak no time should be lost in bailing the molten metal out to a point below the leak, always removing as much dross as possible before taking out the clear metal. At this point it can be decided whether or not to try and repair the kettle and if not, continue the bailing operation until the kettle is empty, always removing the dross first. When bailing out an old kettle do not let the fires cool off too much, thereby allowing the zinc or dross to congeal on the sides, as you may have considerable difficulty in removing it.

When an old kettle, especially a large one, suddenly starts to leak badly it is often advisable to secure considerable extra help in order to remove the dross and metal quickly, thus preventing the molten zinc from running into ash pits or elsewhere and cooling in such a way that it cannot be easily recovered or handled for re-melting. A little extra expense in the matter of labor employed at such a time can easily result in a substantial saving later on.

An ordinary iron molder's ladle with an iron handle makes an excellent tool for bailing out a galvanizing kettle, and several should be kept on hand ready for use if they are liable to be required in such an emergency.

After an old kettle has been bailed out as clean as possible draw the fires and wet it down with water to hasten the cooling off process if necessary, after which remove carefully all bolts, nuts, castings and other iron work for use again. The brick work can then be torn down to the foundation and the old kettle removed, after which the new kettle may be set up on the same foundation, filled with zinc and heated up the same as any new kettle, instructions for which are given on pages 20 to 26 and 66 and 67.

CHAPTER XII

The Schoop Metal Spray Process

ONE of the great metallurgical problems of the day has been to produce a non-corrosive surface on iron and steel, the indispensable but vulnerable materials of engineering construction, without affecting the physical properties of these metals or the shape or usefulness of the object treated.

There are demands in the arts for a method which will take the process to the work or to any part of it, and will secure the quick deposition on any coherent object, whether metallic or not, of any desired metal or alloy in any quantity, however minute.

This is the ideal metal coating process. Inventors have labored over the problem for many years but commercial results have not been developed until recently because of the lack of economy in the earlier forms of apparatus.

The overlaying of iron and steel for temporary effect with non-metallic substances, such as paints, enamel, japan, and varnish, has been the mechanical method necessarily followed hitherto for the great bulk of metal objects and structures and the renewal and maintenance of such protections involves enormous outlays. It is the object of this chapter to describe the latest mechanical process for depositing electro-positive metals, such as tin and zinc, on iron and steel. Incidentally, the method permits of depositing many other metals and alloys on coherent bodies whether metallic or not.

The Process takes its name from M. U. Schoop, an engineer of Zurich, who, in collaboration with other inventors, made the metal spray an effective coating agent. In the Schoop Process, the United States patents for which have just been issued, the coating metal adheres to the object chiefly by mechanical union. The metal is discharged in hot impalpable particles moving with high velocity, and these when directed upon a prepared object penetrate the pores of the latter while the spray is still plastic. The coating metal thus dovetails itself into the superficial pores of the object and does so in the presence of reducing gas, which prevents oxidation at the junction of the metals.

The progress of invention on metal spraying has been chiefly

directed toward making the metallic particles as small and as hot as possible and to avoiding oxidation.

In 1902 Thurston, United States No. 706,701, was granted a patent for impacting, with unignited gas, metal in the form of dust upon a metallic base. His apparatus was not practical and no commercial results were obtained.

Within the past year four United States patents have been issued which embrace all the important steps since Thurston's invention.

Schoop, United States No. 1,128,058, invented a process for producing a fine spray from either molten or solid metal and also for producing separable metallic coatings or copies of the objects sprayed upon; this was known as the liquid metal spraying process.

Schoop, United States No. 1,128,059, later invented a process for projecting finely divided unmolten metal particles on to a surface, using an ignited gas and metal in the form of dust like Thurston. This was known as the metal dust spraying process.

Very soon afterward Morf, United States No. 1,128,175, invented a process for melting, atomizing and projecting, practically simultaneously, solid metal and particularly metal in the form of wire. This was known as the metal wire spraying process.

At the same time Morf, United States No. 1,100,602, invented a successful apparatus (known as a "Pistol"), for effecting this process.

These inventions above outlined form the basis of the Schoop Metal Spray Process as it is now operated in the United States. The present chapter is wholly concerned with the apparatus used for tinning and galvanizing by this method and with the applications possible.

The evolution of the apparatus has been interesting. The liquid metal process involved a large non-portable reservoir of hot metal weighing with the auxiliary parts over a ton; the metal dust apparatus weighed over a hundred pounds, while the "Pistol" of to-day weighs less than four pounds.

Figures A, B, and C show the three forms through which the apparatus has passed.

In the apparatus represented by Fig. A, a melted metal is allowed to run continuously from the reservoir "R" through a broad nozzle "N," where it is broken up and swept away by a violent current of heated gas "G," issuing under regulated pressure from containers "C" and reheated in its passage at "H." The expansion

of the gas chills the molten particles and forms a rapidly moving spray or fog of metal which impacts upon any object placed in its path and plates it.

Any metal fusible under the conditions of the apparatus can be used and owing to the low temperature of the fog, it is possible to plate very delicate or easily combustible objects, as well as metal articles.

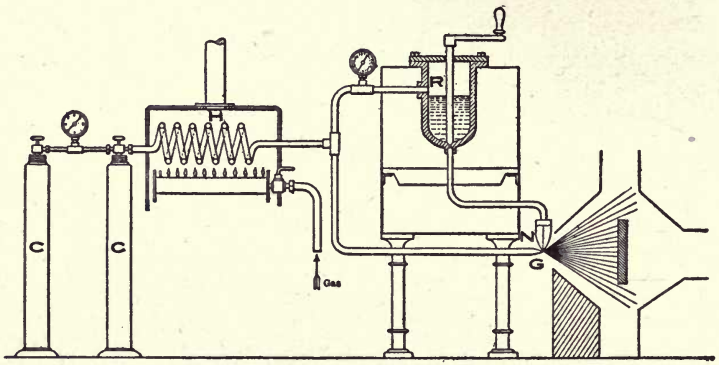

FIG. A—FIRST TYPE OF METAL SPRAY APPARATUS

Aluminum plating, which could not be obtained by fusion or electrolysis on account of its ready oxidation, was easily obtained by the Schoop Process.

The obvious objections to such an apparatus were lack of portability and the expense of melting and keeping fluid most of the metals in the unavoidable intervals of spraying. The result was that only the more fusible metals, zinc and tin, were used where spraying on a continuous scale was possible and the liquid metal apparatus was never reduced to economical practice. It was observed with this apparatus, however, that the particles were not actually molten at the moment of impact and this suggested the next step.

Fig. B represents the second form of apparatus in which portability was secured and the metal particles to be sprayed were prepared in advance. Powdered metals in a very fine state of division have many of the characteristics of a liquid. Their fine particles mix with one another like drops, they spread with facility and unite under the influence of very little force.

The metal powder in the container "C" is entrained in an air

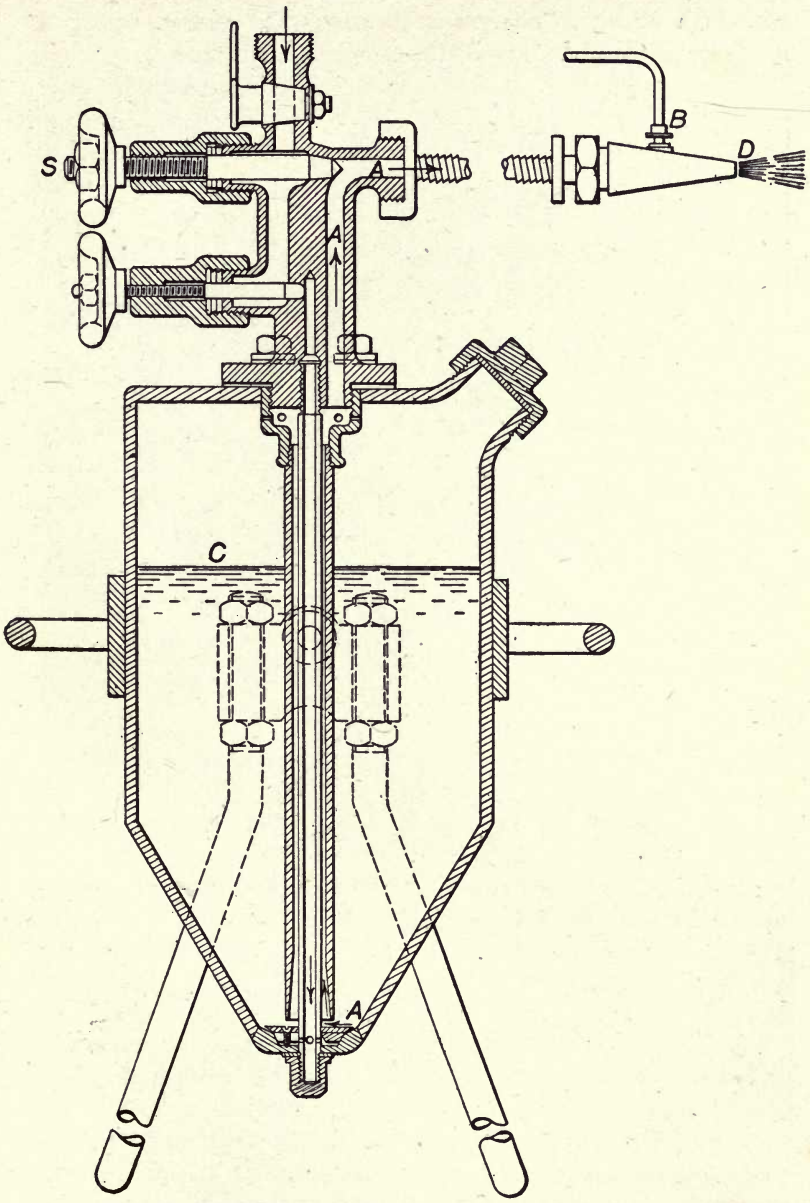

FIG. B—SECOND TYPE, PORTABLE METAL SPRAY APPARATUS

blast "A," heated in the flame of a blast pipe "B" and projected with high velocity. The gas is burned at "A" and the supply of air is regulated at "S" to obtain complete combustion.

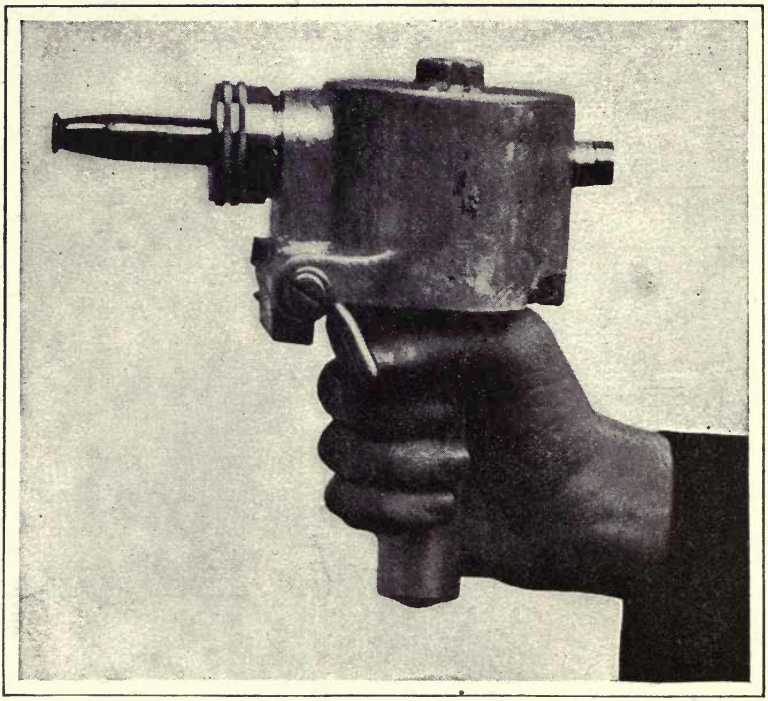

FIG. C—THIRD TYPE OR METAL SPRAY PISTOL

It was found that the anticipations from the use of the first apparatus were correct and that metal particles projected in a

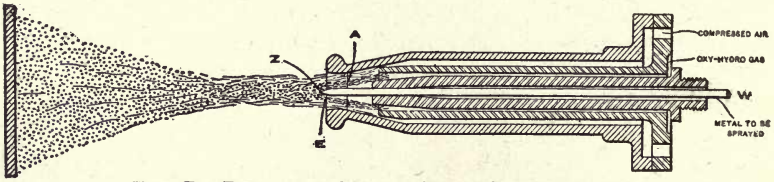

FIG. D—DETAIL OF METAL SPRAY PISTOL NOZZLE

pasty condition produced plating as before. Metal powders, however, are very costly. Most of them tend to oxidize rapidly and the use of this apparatus was practically restricted to zinc on that

account. The zinc is a by-product of Zinc Smelteries and is readily applied by the simple apparatus known as the "Cyclone," which has just been described. It is still the most economical method of producing a Schoop coating of zinc.

Inventors set themselves to overcome both the chemical and

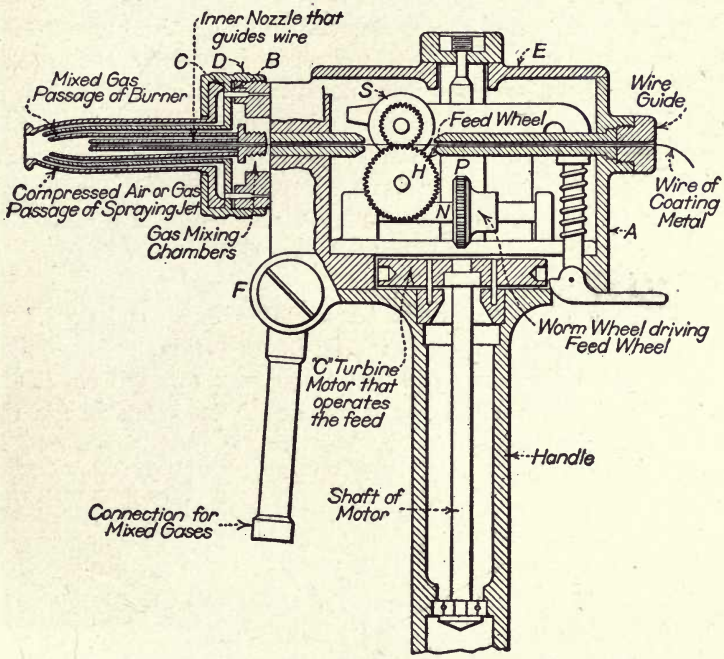

FIG. E—SECTION SHOWING DETAIL OF CONSTRUCTION OF PISTOL

economic difficulties with other metals including tin, viz.: to dispense with mass melting and dust preparation and to secure instant and simultaneous melting, and pulverization, and control with a handy, economical appliance. The result was the ingenious instrument known as the "Pistol," which is shown in Fig. C.

The principle (Fig. D) consists in feeding a fine wire "W" of any metal into a reducing flame zone "Z" at such a constant speed that the end of the wire "E" remains stationary, its melting rate being exactly equal to the rate of feed. Under such conditions the wire end melts a drop at a time and each drop at the instant of formation is struck a violent blow by an air blast "A."

The resulting fog or spray of fine particles into which the drops

are divided takes the form of a diverging cone "C" with a core of reducing gas "G" in which the particles are entrained, and a surrounding sheath of air "A," which is rapidly expanding and cooling. Any suitably prepared object placed in the path of this metallic spray is plated through impact without undue elevation of temperature.

Fig. E is a section of the commercial spraying pistol now in use. The principal parts of the pistol consist of an outer casing "A," cast of aluminum, with a central downward projecting tube forming a handle, a wire feed mechanism mounted entirely upon the cover "B," of the turbine chamber, the turbine "C," actuating the wire feed mechanism, gas, air and wire nozzles mounted upon the outer casing held in position by a hand nut "D," and a removable cover "F," which completes the enclosure of the outer casing.

Gas and air ducts are drilled in the outer casing, the flow controlled by the tapered valve "F" provided with a handle "G."

The wire feed mechanism is actuated by a turbine "C" mounted on a vertical shaft running in ball bearings; a worm is cut in the upper end of the vertical shaft and drives by worm wheels the horizontal shafts "N" and "O", which are provided with worms in turn driving the worm wheels "P" and "Q."

The worms "P" and "Q" are provided with slots to engage the projecting lugs of the lower feed wheel "R." The upper feed wheel "S" mounted in the pivoted frame "T" is provided with shrouds controlling the position of the lower feed wheel "R." The lower feed wheel can be engaged in either work "P" or "Q" by raising a clip "I" shifting laterally in either direction and locked in by the opposite clip. The shift can be readily made by allowing the mechanism to run slowly by a slight opening of the starting valve.

Pressure is applied to the feed wheels through the pivoted frame "T" by a coiled spring, and controlled by the operator by means of the release lever "K."

The final adjustment of the wire feed is controlled by the needle valve "M." The turbine and shaft complete is assembled in the outer case and properly adjusted independently of other mechanism.

The wire feed is entirely assembled on the turbine cover "D" and when properly adjusted, secured in position. The wire nozzle

base "U" provides an adjustment for position of wire and gas nozzles, and is secured in position by a headless set screw.

The upper end of the stem of the turbine cover is provided with an annular groove, which is engaged by the spring loop "V" and secures the removable cover "E" of the case. Loop "V" provides a means for hanging the pistol on a conveniently located hook.

The Operation of the Pistol

The gas and blast nozzle faces, "B" and "C," are securely clamped to form gas tight joints by tightening the hand nut "D." The end of the central or wire nozzle is then .015″ inside the gas nozzle and the stationary melting point of the wire is .03″ inside the air blast nozzle. The wire diameter used is from .0319″ to .0375″, except zinc and tin, which are used in larger sizes, owing to their rapidity of melting.

The feed gears having been set in mesh at the approximate speed required for the wire selected, the air alone is turned on and the speed tested with a short length of wire. Adjustment, if necessary, is made by the needle valve, which modifies the speed two feet per minute plus or minus.

The end of the wire reel is then threaded through the stock receiving tube, between the gripping feed rolls and into the central wire nozzle and the fuel gas pressures from the containers are adjusted by the reducing valves and gauges thereon to the tabular requirements for the metal to be sprayed. The pressures of the fuel gases seldom rise above one atmosphere and hydrogen or Blau gas are the reducing gases usually employed. This gas is now admitted by slightly opening the starting valve and when ignited with a match burns quietly as a pilot light.

The starting valve is then opened up full and oxygen is admitted gradually till the flame zone is established. All back-firing is avoided by keeping the reducing gas always in excess of the oxygen, the ratio being three or four to one. The above movements are made in rapid succession on a light instrument which can be held in one hand and the spray is started up the moment the constant melting position of the wire is reached.

The spray so established is essentially a metal plating air-brush of which the diameter 5″ from the pistol end is about 2″. Objects to be plated are operated upon by pointing the pistol normally to the surface to be coated at any moment at about five (5)

inches distance and traversing the pistol across the surface with a regular motion.

A single coating is about .001″ thick. The operator's vision easily guides him in distinguishing between the coated and uncoated portions and also between a first and second coat.

Two thousandths of an inch well impacted upon a surface are just as effective as a much greater thickness and of course unnecessary sprayed metal increases the cost, as the latter is directly proportional to the thickness.

Not only on the score of economy but also to preserve toughness the coating should be of minimum thickness, for the anvil action of the metallic spray on a solid metal object is lost above a few thousandths of an inch thickness and a process of cold working follows which produces a brittle scale readily detachable.

In practice this matter is easily regulated. Fig. C shows the pistol held in the hand ready for action with the wire thread in position. Fig. F shows the pistol applied to coat a wooden pattern for protection with tin. Gas bombs with fittings and air at 40 pounds pressure are the only requisites besides the "Pistol" and its hose connections for plating non-metallic objects such as wood, stone, paper, cement, cloth, etc. All metallic surfaces should have the scale cleaned off and their pores opened by preliminary sand-blasting.

It will be seen from the tables appended that .001″ thickness, one square foot in area, of the common metals can be sprayed for a small sum. The total cost is five cents per square foot for tin and two cents per square foot for zinc.

Various theories have been offered to account for the plating properties of the Metal Spray, but it is believed by those putting it to practical use that, except in the few cases where the impacted metals have a chemical affinity, the action of the spray is purely mechanical and restricted to superficial pores of the object.

Metal Spraying is essentially a kinetic energy process and the "Pistol" is practically a rapid fire gun which manufactures its own ammunition automatically from a reel of wire and discharges an infinite number of projectiles which impact themselves in the exposed pores of any object five inches away. In the zinc dust "Cyclone" apparatus the size of the projected particle is predetermined, but the action at the object is identical with that of the

"Pistol." In either case with proper preparation of clean, open surfaces a durable, adherent, protective coating is attained.

In general, the applications of the Metal Spray Process may be divided into five groups, namely, protective coatings; bonding or

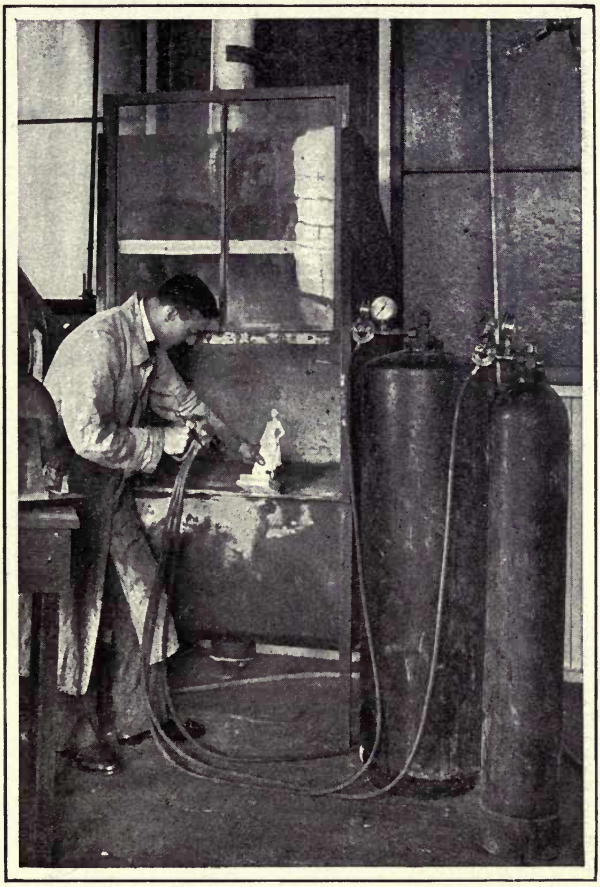

FIG. F—METHOD OF USING PISTOL IN SPRAYING

junction coatings; electrical coatings; decorative coatings; and detachable coatings or copies of the objects.

Protective coatings on steel or iron may be either original coatings of the whole of an object or structure, or they may be confined to any part of it, or they may be merely local applications with the

"Pistol" or "Cyclone" apparatus to repair damage or wear to a coating of tin or zinc made by another process. The repair of the troublesome defects found on many galvanized and tinned sheets, and leading to their rejection, is an application of this process which is made only through the possibility of applying tin or zinc to any area, however small, and confining it to that area. Another application for the same cause is the filling up of pin holes in expensive machine castings, such as printing rolls, etc., which would otherwise be a complete loss.

Many engineering structures used in the arts, such as steel and iron tanks, bridges, girders, and machinery of all descriptions, corrode rapidly, particularly at joints, especially if exposed to atmosphere or liquids. It is not possible to plate such structures by any other coating method than the Schoop Process. In such cases tin or zinc may be applied from dust or wire form on all seams and joints or all over the structure, surfaces having been previously cleaned by a light sand-blasting. This treatment can be made on the parts of individual members at the shops or in the field by portable cyclone and compressor outfits wherever the nozzle of the apparatus can be pointed normally to any surface. Proper initial treatment of this kind or in the field during erection dispenses with all need for repeated painting.

Laundry machinery, milking machinery, dairy utensils, water heaters, and similar appliances subject to corrosion can be protected against decay due to electrolysis by sprayed deposits of zinc suitably located. The Schoop coatings do not compete in cost with the ordinary tinning or galvanizing applied to tonnage goods and purely temporary in its effects. From the table appended, however, showing the data of gas consumption and total cost of spraying a square foot .001″ thick of all the commoner metals, it will be seen that tin and zinc can be applied effectively for 2½ cents per square foot; where zinc dust is applied by the "cyclone" apparatus it can be done for 1½ cents per square foot.

DETAIL COST OF USING PISTOL ONE HOUR

METAL	Diam. Inches	Speed of Wire in Feet per Min.	Pounds per Hour	OXYGEN			BLAUGAS			Labor per Hour	Cost of Air per Hour	Cost of Spray'g	Wire Cost per Hour	Total Cost per Hour	Total Cost per Minute
				Gauge Press	Cubic Feet	Cost at $.02 Cu. Ft.	Gauge Press	Cubic Feet	Cost at $.008 Cu. Ft.						
Copper	.032	12	2.15	27	24	$.48	$25	$13	$.104	$.30	$.20	1.08	$.366	$1.446	$ .0241
Brass	.032	12	2.15	28	21	.42	26	14	.11	.30	.20	1.03	.335	1.365	.0228
Bronze	.032	12	2.15	27	24	.48	25	14.5	.116	.30	.20	1.09	.432	1.522	.0253
German Silver	.032	12	2.15	28	23	.46	26	14	.11	.30	.20	1.08	.545	1.625	.0271
Aluminum	.0375	16	12.	19	36	.72	16	13	.104	.30	.20	.32	.44	.76	.0127
Zinc	.0375	18	4.3	15	20	.40	13.5	10	08	.30	.20	.98	1.23	2.21	.0368
Lead	.076	25	30.	14	20	.40	12	8	.064	.30	.20	.964	3.00	3.964	.0661
Tin	.061	25	15.	13	24	.48	14	10	.08	.30	.20	1.06	10.50	11.56	.1933

COST TO COVER ONE SQUARE FOOT

METAL	Diam. Inches	Speed of Wire per Minute	Time to Cov. One Sq. Foot		Thickness Inches	Cost of Spraying	Cost of Wire	Total Cost
			Min.	Sec.				
Copper	.032	12	1	10	.001	$.021	$.0076	.0286
Brass	.032	12	1	10	.001	.020	.0071	.0271
Bronze	.032	12	1	10	.001	.024	.0101	.0341
German Silver	.032	12	1	10	.0089	.024	.0105	.0345
Aluminum		16	—	40	.001	.0128	.0042	.0170
Zinc		18	—	30	.0015	.0081	.0115	.0196
Lead	.076	25	—	25	.002	.0064	.021	.0274
Tin	.062	25	—	30	.002	.0088	.0875	.0963

COST OF SPRAYING ONE POUND

Feet per Pound	Speed of Wire in Feet per Minute	Time to Spray One Lb. Minute	Cost of Spray'g	Cost of Wire	Total Cost
340	12	23	$.50	$.1725	$.6725
350	12	28	.47	.1625	.6325
344	12	28	.53	.2225	.7525
330	12	28	.51	.25	.76
761	16	48	1.075	.37	1.445
283	18	14	.227	.33	.557
50	25	2	.032	.10	.132
105	25	4	.07	.70	.77

CHAPTER XIII

Tinning Malleable Iron Castings, Wrought Iron and Steel

TO SIMPLY give articles of malleable and wrought iron a coating of tin is a comparatively easy process to master, but the tinning of certain classes of hardware has reached a high state of perfection, and to tin saddlery hardware and table cutlery requires considerable skill. The methods employed to do the work vary greatly in different establishments, and the degree of perfection attained is equally varied. Work that is tinned in an indifferent and slovenly manner is not necessarily done cheaply, as the metal wasted on an article that is roughly and imperfectly coated may be of more value than the slight saving in labor cost obtained by rushing the work through without giving proper attention to the applying of a light and even coating. The high price of pig tin makes the material cost of tinning much more than the labor cost. The use of care in bringing the finished articles out free from surplus tin not only adds greatly to the commercial appearance of the goods, but materially decreases the cost of the work. The most economical result is obtained by careful attention to the heat of the tinning bath and to the skillful handling of the articles during their removal from it and before they are cooled. If the tin is not hot enough the articles will be heavily coated, and it will cool on the work bunchy and wavy. Tin when heated above a certain limit also causes a rough and uneven appearance of the work, injures its color and destroys the luster. The use of a good pyrometer in a tinning bath is a great help to the operator in maintaining a proper and uniform heat of the tin. Care in keeping the tin free from dross or slag is an important point in obtaining perfect work and will be referred to in its proper place.

Plant and Equipment

When installing a tinning plant convenient arrangement for handling the work should be given all the consideration possible, and the operator will find it a great help toward making his work

easy, as well as efficient, if he will study to improve methods and tools employed in handling the various articles that come to him for tinning.

While it is our purpose to treat the subject of tinning in a manner that will enable a novice to make a successful beginning, the best results can, of course, only be reached by actual experience. With the principles and requisites necessary to perfect results well understood no trouble should be experienced by one of average mechanical ability in mastering the business.

To make the different operations of preparing and tinning articles of malleable iron, wrought iron and steel easily understood, we shall treat each operation separately.

While the illustrations we give will serve as a general guide in equipping a plant, it does not follow that they cannot be changed to suit local conditions. It would be impossible to illustrate here the exact plan best to follow in each individual case, and those undertaking the installation of a plant must be governed to a great extent by their requirements as they see them.

It should be kept in mind when deciding what part of the factory can best be devoted to the tinning department that more or less gases and fumes prevail while the work is carried on. These gases and fumes are not only disagreeable to inhale, but are destructive to fine machinery, tools and finished work. That the work may not become a source of annoyance to those who are not immediately engaged in it or destructive to machinery and stock, the tinning plant should be located if possible in a building by itself, taking care to provide good ventilation and drainage.

A room devoted to this work should not be less than 10 feet in height, and it is a good plan to provide the kettles and acid tanks with hoods connected with ventilators to carry off the fumes. The hoods should, of course, be high enough to prevent interference with the work of the operators.

The illustrations show tanks of cypress or pine for containing the different solutions used in preparing and finishing the work, but oil barrels sawed in half may be employed for the purpose if they are properly cleaned inside, either by burning or washing in a hot, strong solution of soda ash and water.

For heating the tin hard coal is best, as it gives the most uniform heat and is most easily controlled. Soft coal, coke, natural gas and even wood can, however, be employed for the purpose.

Plan of a Tinning Plant

We show in Fig. 42 a ground plan of a tinning plant intended for general work, except the tinning of common cast iron. In this illustration A is the roughing kettle—that is, the kettle used to give the work its first coating of tin; B is the finishing kettle; C is the tank containing muriate of zinc; D is what is termed in

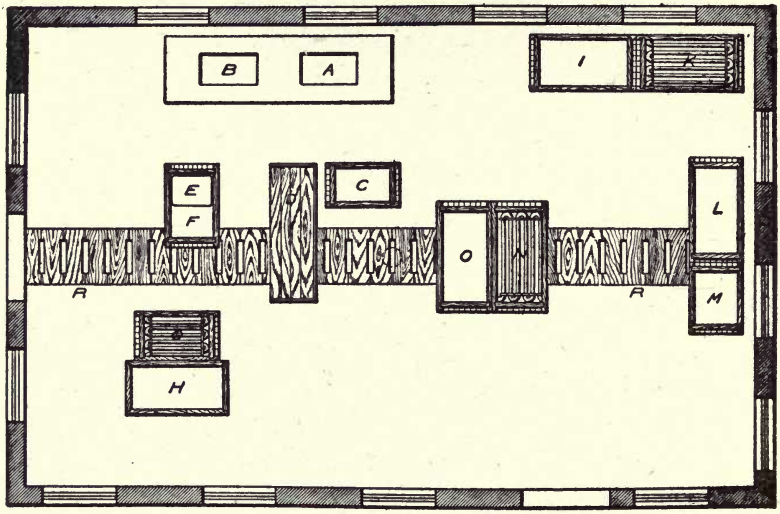

FIG. 42—ARRANGEMENT OF EQUIPMENT IN A TINNING PLANT

the trade the "whipping box," and is simply an arrangement to prevent the drops of molten tin being thrown promiscuously around the room when the operator is shaking or swinging his work to free it from surplus metal; E is a tank made of sheet iron for containing the kerosene oil used to cool the work in, the intent being to have this tank surrounded by cold running water to keep the oil cool, the water being contained in the companion tank F; G is a tank provided with a steam coil, the intent being to keep the tank filled with clean, hot water, in which to rinse the finished work before drying it off in the sawdust, which is contained in the box H; I and O are water tanks used for storing the work after it has been cleaned in the acid; K is a tank containing muriatic or sulphuric acid; L and M are acid tanks, the use of which will be explained in the proper place; N is a tank for containing a hot alkali solution, and it should be provided with

a steam coil; R denotes a drain through the center of the room for carrying off the waste water. A sectional plan of this floor is given in Fig. 43.

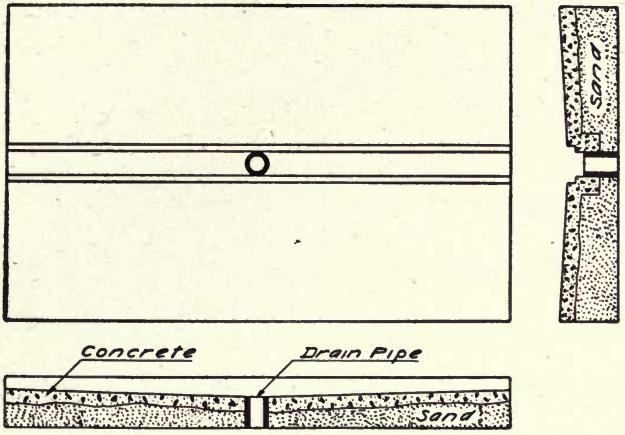

FIG. 43—DETAILS OF FLOOR CONSTRUCTION, SHOWING DRAIN

Tools and Kettles

The tools employed in handling the work are very simple in construction. They consist of wires formed into various shapes, ladles or baskets made from perforated sheet iron or wire cloth, and tongs with jaws formed to hold the various articles to be handled with them. Those illustrated by Fig. 25 in chapter on galvanizing will be found useful and all that will be required in many cases. The ingenuity of the operator will readily suggest what tools are required for the work in hand.

The number of tinning kettles necessary depends altogether on the class of goods to be tinned. The most common kinds of hardware specialties can be tinned very satisfactorily in a single kettle, while the better class of tinning, such as saddlery hardware, iron spoons, etc., require two kettles for best results, and even three may sometimes be employed to good advantage.

Where a plant is fitted up for a fine grade of tinning, the kettle used to give the castings their first coating is called a "roughing" kettle, and the other kettle or kettles the "finishing." When a roughing kettle is used no particular care is taken to have the articles come from it smoothly coated or free from surplus tin, as

the unevenness of the coating will be removed by their treatment in finishing. The object of the roughing kettle is to give the iron a thorough coating of tin, as rapidly as it is prepared for receiving it, to prevent rusting. After the iron receives a thorough roughing coat it may be stored away until required for finishing.

For those having only a small amount of tinning to do it would not pay to invest in an expensive outfit of wet rolling barrels, and very good results can be obtained without them. In fact, only a few of the larger concerns engaged in tinning are so fitted, and their work is of a nature that requires the best results possible to obtain in the way of smoothness and brightness of finish.

CHAPTER XIV

Preparing the Work for Tinning

ORDINARILY the common grades of tinned articles are made ready for tinning by simply removing the sand, scale or rust by pickling in commercial sulphuric, muriatic or hydrofluoric acid, but the finer grades of work are prepared for tinning by careful and lengthy treatment in the water rolling barrel.

Removing Scale and Rust with Sulphuric Acid

Before steel and wrought iron will take a coating of tin all scale and rust must be removed. This is best accomplished with a pickle composed of 1 part sulphuric acid to about 30 to 40 of water, bringing the solution to a temperature of about 150 degrees F.

If the articles are of such shape that they will pack closely together they must be stirred at intervals while pickling so the acid will have free action on all parts alike, otherwise the scale or rust will not be removed on the parts that come in contact with each other, the result being that the acid will burn the material exposed to the action of the pickle before the scale could possibly be removed from the parts in contact.

In pickling sheets they must be placed in racks that will prevent one sheet lying against another. Sheets should be carefully inspected, and any spots that the acid has not touched must be removed with the aid of a sharp-pointed steel tool. The shank of an old file ground to a point and hardened answers the purpose very well.

If the articles are small, and it is desired to give them a fine surface, roll them in gravel and water after removing the scale and rust with the acid solution, and to further improve their surface give them a second rolling in scraps of leather. The effect of rolling is to give the articles a smooth surface, and the smoother the surface obtained in preparing, the smoother and brighter will be the goods after tinning.

We do not wish it to be understood that the rolling operation is

absolutely necessary to obtain a complete coating of the goods, as they will take the tin perfectly if that operation is omitted, provided they are properly cleaned, but their appearance is greatly improved by rolling, and when it is desired to obtain the best finish possible the rolling barrel must be employed.

When the removal of scale and rust has been accomplished and the material is perfectly clean it should be stored in tanks containing clear water, there to remain until the operator is ready to put it through the subsequent operations. Do not allow the work to remain in running water, as it will soon rust or oxidize.

The operator must not fail to examine the work frequently while it remains in the hot pickle to determine when the desired result has been obtained. If it is allowed to remain too long a time after the scale and rust have been removed the acid will attack the surface of the material and leave it rough and seamed. Imperfections caused by overpickling cannot be eliminated by the coating of tin, and the commercial appearance of the goods will be injured.

Cleaning Sandy Castings with Sulphuric Acid

Castings that have sand on them must be subjected to a treatment that will effectually remove it, as a perfect coating cannot be obtained if sand remains. The removal of sand can be accomplished by placing the castings on an inclined platform and keeping them wet with a cold pickle composed of 1 part sulphuric acid to 6 of water, until the sand is loosened enough to be washed off by a stream of water. From 10 to 20 hours is required to accomplish its removal, and then a casting brush must often be employed to remove all the small particles that are burned in where there are sharp angles.

Rolling with plenty of sharp scratches or stars is the only sure way to obtain a perfectly smooth, clean casting, and we should never attempt to tin malleable castings in any considerable quantity without the aid of a rolling barrel. As in the case of steel or wrought iron articles, the wet rolling barrel supplemented by the dry rolling in leather scraps fits the castings to take a beautiful coating of tin with a bright luster.

The platform on which castings are placed for pickling with sulphuric acid should have a tank placed under one end at its lowest point to catch the acid as it flows from the castings after each bailing operation.

Cleaning with Muriatic Acid

The removal of scale and rust from wrought iron and steel can be accomplished by a pickle composed of 1 part muriatic acid to 15 to 20 parts of water, but the cost is greater and the result obtained no better. It is not advisable to use this acid for the purpose unless the amount of work to be treated is very limited and the sulphuric acid pickle is not available.

In Fig. 42 K represents a tank to be used for the sulphuric or muriatic pickle, and I indicates the storage tank for the prepared work.

Cleaning Sandy Castings with Hydrofluoric Acid

We have given the course to be followed for cleaning sandy castings with sulphuric acid, because it may not always be possible to obtain hydrofluoric acid. Where it is possible to substitute this powerful acid for sulphuric it should be employed, as its action is much more rapid and certain, and less destructive to the castings.

In employing hydrofluoric acid to remove sand make a solution for slow pickling in the proportion of 1 part acid to 30 of water. For quick pickling make the proportion 1 of acid to 20 of water. Immerse the castings until the sand is dissolved, which will be in from 15 minutes to 3 hours, depending on the strength and temperature of the solution and the tenaciousness of the sand.

A good arrangement for doing this work is made by two or more small tanks for containing the castings elevated by a bench or stand a few inches above a larger tank containing the pickling solution. The castings are covered by solution bailed from the lower tank, which is easily drawn off after the castings are pickled by removing plugs fitted to holes in the bottoms of the smaller tanks. In this way the pickling solution can be used over and over again, while the castings can be easily removed for subsequent treatments.

Water Rolling

This method of preparation not only effectually removes all impediments to a perfect coating, but gives the articles a perfectly smooth surface on which to deposit the tin, the degree of perfection obtained being determined by the time and care expended in the rolling operation. Further information on the rolling and

tumbling of cast, wrought and malleable iron to be tinned is given in Chapter VI, pages 51 to 65.

Removing Paint or Grease

If the work has grease or paint on it, it must be removed and the sand blast will be found of great value for this work, although a hot solution of caustic soda or soda ash will often times accomplish the desired result. Make the solution very hot and strong, and immerse the work in it until free from all such matter, after which rinse it thoroughly in clean water. This operation should precede pickling when necessary to perform it. The tanks for this purpose are designated in Fig. 42 as N and O; N being the caustic soda tank and O the rinsing tank.

CHAPTER XV

Applying the Coating of Tin

AS ALREADY stated, very good results can be obtained by simply using one kettle of tin when the commercial appearance of the work is of secondary importance. Where only a single kettle is employed the tin should be maintained at a temperature of about 500 degrees F., and the work may be cooled in hot water and dried off in sawdust.

The operations preliminary to dipping the work in the tinning bath are precisely what they would be if more than one kettle was used. As these operations will be explained in connection with those for using two kettles, we will not give them here.

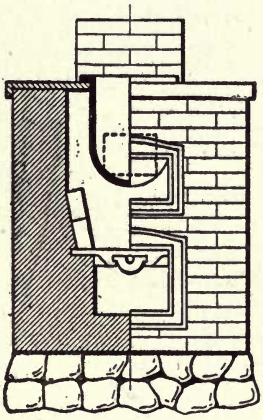

FIG. 44 — FRONT ELEVATION

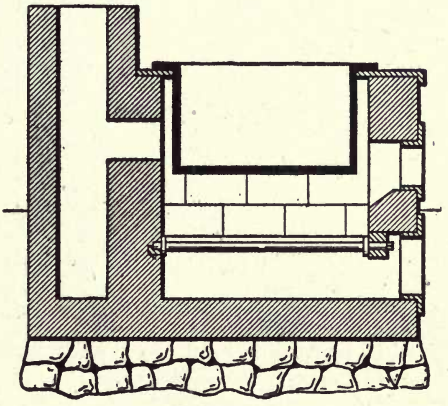

FIG. 45—SIDE ELEVATION

Details of Tinning Kettle

Where only a single kettle is employed more or less trouble will be experienced in keeping the dross or slag which rises to the surface of the tin from adhering to the work, and in keeping the tin at a uniform temperature. The dross or slag must be removed from the tin frequently with a perforated skimmer, and when the black flux that forms on the surface of the tin from the muriate of zinc, in which the castings are dipped previous to immersing

them in the molten tin, becomes present in sufficient quantities to interfere with drawing the work, it must also be removed in part. A small amount aids in the work, but when it accumulates in a sufficient quantity to catch on the work as it is drawn out it is apt to stain the work and leave white streaks wherever it touches. The cooling water should also be kept clean and free from acid. If it is not, the work is liable to be discolored and rust. In Figs. 44, 45 and 46 we show manner of bricking in a single kettle, the casting details being shown in Fig. 47.

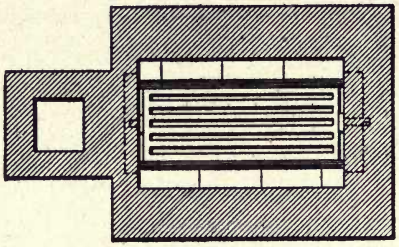

FIG. 46—PLAN AT GRATE LINE

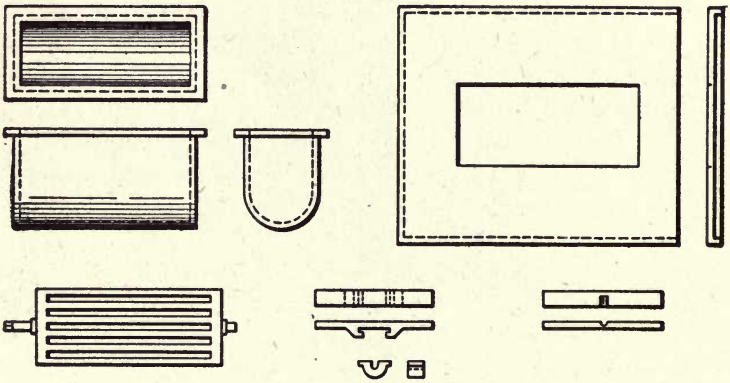

FIG. 47—CASTINGS REQUIRED FOR TINNING KETTLE

Tinning with Two or More Kettles of Tin

When the work has been made perfectly clean and free from sand, scale, rust, grease or paint by some one of the treatments described, it is ready for the final operations. If the work is of a kind that will admit of its being strung on wires, use such wires as seem best adapted to the work in hand. For many kinds of work a piece of wire bent in the shape of a croquet wicket, but larger, will be just the thing. Good stiff wires should be used, and they should be long enough to allow plenty of room for the operator

to grasp the ends without being burned. That is to say, if you have 10 inches of tin in the kettle, make the end of the wire 20 inches long, which will allow 10 inches of wire out of the tin where the operator can grasp it when he is ready to draw the work from the kettle. Provide plenty of these wires so that the handling of the work may be facilitated.

String on wires as much of the work as you think you can handle comfortably, and put them, several strings at a time, into the alkali solution. The work may be allowed to remain in this solution for several minutes, or while the operator is filling more wires. From the alkali solution the work is to be passed into the rinsing tank, where care should be taken that all traces of the alkali are removed.

When this is accomplished the work is to be given a few minutes' immersion in a solution of muriatic acid and water. This mixture should be in the proportion of 1 of acid to 4 or 5 of water in cold weather, while in warm weather 8 or 10 of water to 1 of acid will do the required work. The object of this dip is to remove any trace of rust that may have formed on the work. The tank for this purpose is designated as K in Fig. 42, and for many kinds of work, such as castings that have been cleaned by dry rolling, and goods made of material that has no scale, all that is necessary is to give it a few minutes' immersion in this solution.

After this last dip of muriatic acid and water, which by the way should never be omitted, the work is to be dipped in muriate of zinc, which is the last dip previous to immersing it in the molten tin. Tank C, Fig. 42, is used to contain the muriate of zinc, which solution is made by dissolving scraps of zinc in clear muriatic acid.

Passing the Work Through the Tinning Kettle

If two kettles of tin are in use, as shown in Fig. 42 by A and B, take a wire full of work to be dipped and plunge it while wet with muriate of zinc into the tin in the roughing kettle, designated in Fig. 42 as A. Put several strings of work into the kettle at once and allow them to remain until the work is as hot as the tin, which, in this kettle, should be maintained at a heat of about 500 degrees F.

After the work has remained in the roughing kettle for the required time take a wire full in the left hand, and with a skimmer

in the right hand clear a space on the surface of the tin large enough to permit the wire full of work being removed without any of the dross or flux adhering to it. Remove the wire full of work and pass it directly to the second kettle. It is not necessary to shake off the surplus tin when removing work from the first kettle, but it is necessary to use care that none of the flux or slag is carried over to the second kettle on the work.

While retaining hold of the wire the operator allows the work to remain in the second kettle for a fraction of a minute until the heat of the work attained in the first kettle is reduced to about the temperature of the tin in the second kettle, which for most purposes should be about 400 degrees F. Very small articles may require that the tin in the second kettle attain a temperature of 450 degrees F. A little higher heat will cause the tallow, which is on the surface of the second kettle, to a depth of ½ to 1 inch, to ignite. When the work has about reached the heat of the metal draw it quickly from the tin, and after a few rapid swinging motions to free it of surplus metal plunge it into the tank of kerosene oil, using motions calculated to keep the articles from sticking together. A little practice will soon determine what motion is best for keeping the articles separated and preventing lumps of tin from forming on the work.

D in Fig. 42 denotes the position of the box provided to catch the drops of surplus tin that are thrown from the work as the operator swings it to and fro. E denotes the tank for containing kerosene used for cooling, as already explained, and this tank should be surrounded by running water to prevent the oil heating to a point where it would ignite.

The work should be allowed to remain in the oil long enough to set the coating of tin, and should then be dipped in hot water and thrown into fine dry sawdust to dry it and remove the oil. If the articles are very heavy it may be necessary to plunge them into cold water after the oil.

If small work cannot be strung on wires a "basket" may be used for dipping it. The basket may be made of sheet iron, in which case it should be well perforated to allow the tin to escape, or it may be made of wire cloth of a mesh sufficiently small to prevent the work falling through. Fig. 25 illustrates the shape of these baskets, which are designated as A and B. Nails, tacks, rivets and all similar small articles are tinned by means of these baskets.

Tongs are used for handling heavy articles, but those used in the tin should not be used for cooling the work, as they would mark it. The tongs used for cooling should not be put into the molten tin. The shape of tongs should be made to suit the form of the article to be handled.

Tinning Wire in Coils

In large manufacturing establishments machinery is employed with which several strands of wire are passed through the tinning kettle simultaneously. To do the work on a small scale, provide reels that will accommodate a coil of wire. Place one of the reels in a position where the black wire will pass, as it is uncoiled, through a tank containing muriate of zinc through the kettle of tin. The other reel should be placed in a position where it will coil up the wire as it is drawn out of the tin. The reel used to draw the wire through the kettle must, of course, be provided with an arrangement for revolving it, and a device to hold the wire under the muriate of zinc and also under the tin as it passes through must be employed. As the necessary arrangement will readily suggest itself we do not think it necessary to illustrate it.

At the point where the wire leaves the molten tin a piece of tow is twisted around the strand, sufficiently tight to wipe off the surplus metal, which flows back into the kettle. If the wire is very heavy it must pass through water after it leaves the tin, the water tank being placed where the wire will not enter it until it has passed through the bunch of tow used for wiping off the surplus metal.

If the wire is covered with a heavy scale or rust it must be cleaned in sulphuric acid the same as any other wrought iron or steel. If it is bright wire all that is necessary is to immerse it in a solution of muriatic acid and water, 1 part acid to 6 of water. If wire is to be tinned in large quantities a long, shallow kettle is best adapted to the purpose.

Tinning Steel Spoons and Similar Articles

For this purpose provide a good sized kettle for "roughing" the work— that is, for giving the first coating. For finishing the work use small kettles. A kettle 15 inches long, 8 inches wide and 6 inches deep is amply large for finishing work of this kind. We refer to a plant fitted especially for this business. The work can

be done in an outfit such as we illustrate by Fig. 42, but large finishing kettles are not as well adapted to this business as small ones, as the tin in a large kettle is apt to become dull in color by constant use, while in a small kettle the tin is renewed more often, which allows it to hold its color much better.

In preparing the articles they should be rolled in tumbling barrels with scraps of leather and then carefully cleaned in an alkali solution. After rinsing off the alkali they should be immersed in quite a strong solution of muriatic acid and water for five or ten minutes, and then dipped in the roughing kettle by means of a wire basket, first dipping the work in a solution of muriate of zinc. As soon as they are thoroughly coated shake them out of the basket in such a way as to insure the separation of as many as possible. It makes no difference whether they come smooth or not so long as they are thoroughly coated. The smoothness will come in the finishing operation.

To finish the goods take one piece at a time in a pair of tongs adapted to holding them and immerse them in the finishing kettle, the tin in which is covered with beef tallow to the depth of about $\frac{1}{2}$ inch. As soon as the article reaches the same heat as the tin remove it and allow it to cool until the tin will not run, after which wipe off the goods in flour.

CHAPTER XVI

Re-Tinning

THE term re-tinning refers to the re-coating of pressed or stamped ware with tin. In the process of manufacturing tinware from tin plate by stamping or pressing, the original coating on the sheets is partly destroyed; hence, it becomes necessary to "re-tin" them; i.e., give them another coat of tin. It requires no little amount of skill to operate a re-tinning plant successfully, and satisfactory results are only obtained after long practice. For this reason, we omitted any extended mention of the art of re-tinning in the first issue of "Galvanizing and Tinning." Since the book was published, however, we have had so many communications from parties seeking information on the subject that we have decided to try and explain the process to the best of our ability. While perhaps our explanation will not enable the unskilled to successfully operate a re-tinning plant, it is hoped that what we have to say on the subject will not only prove of assistance to the novice, but to those already engaged in the business.

Plant and Equipment

The illustrations show the construction of a re-tinning stack without going into dimensions, as the dimensions of the various kettles can only be determined by the class of work that it is desired to handle. We might say, however, that our illustrations of the kettles and brickwork of a re-tinning stack were made from a plant in operation on re-tinning ordinary kitchen ware, such as pressed dish pans, wash basins, etc., etc.; the actual dimensions of the kettles designated as A and C in Fig. 48 being 30″ square. The dimensions of the kettle shown in the same Figure as B are 24″ wide, 30″ long and 24″ deep, while the small kettle designated as D, known as the "listing" kettle, is 6″ wide, 12″ long and from 3″ to 4″ deep.

As indicated by Figs. 48 and 49 the outfit for a re-tinning plant consists of four kettles. A is what is known as the "soaking" kettle, and is used to contain molten beef tallow. B contains the

molten tin and is known as the "tinning" kettle. C contains beef tallow and is known as the "finishing" kettle, while D contains molten tin and is known as the "listing" kettle.

The soaking kettle A contains beef tallow. In this kettle are immersed in rotation articles to be re-tinned. When the goods are received in the re-tinning room from the stamping room for

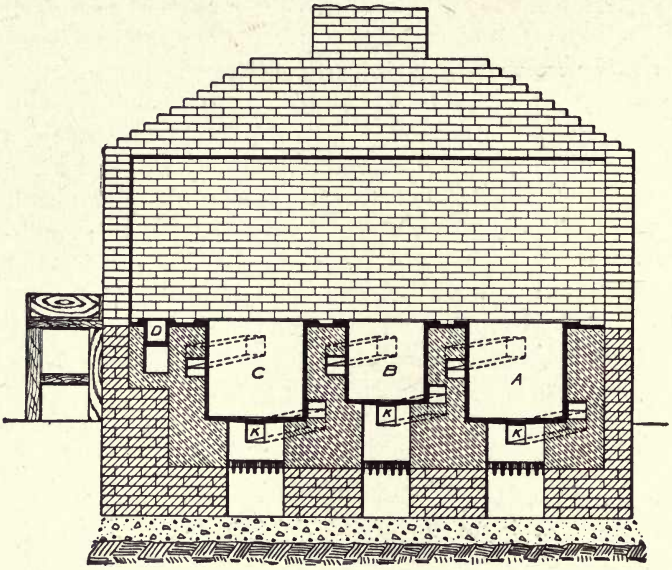

FIG. 48—RE-TINNING FURNACE

re-tinning, they are covered with various substances that have been used in the stamping room to facilitate the stamping operation. This foreign substance usually consists of a solution of grease and soap, which must be removed before the articles are in proper condition for re-tinning. The soaking kettle is required not only for the removal of all foreign substance that has accumulated on the articles in the process of stamping, but to bring them to the proper heat for immersing in the tinning kettle B. In order to have the work proceed uniformly and systematically the soaking kettle A is provided with a rack or container, the general construction of which we illustrate by Fig. 50. The intent of these racks or containers is to prevent the articles from "nesting" together in the soaking kettle, thus retarding or entirely

defeating the object for which this kettle is used. Hence, it is obvious that these racks or containers must be made with a view to the proper accommodation of the articles to be handled. For instance, what is known to the trade as a six-quart pan would require a rack or container of a different size than would be used for a pan or article twice its size. The rack or container

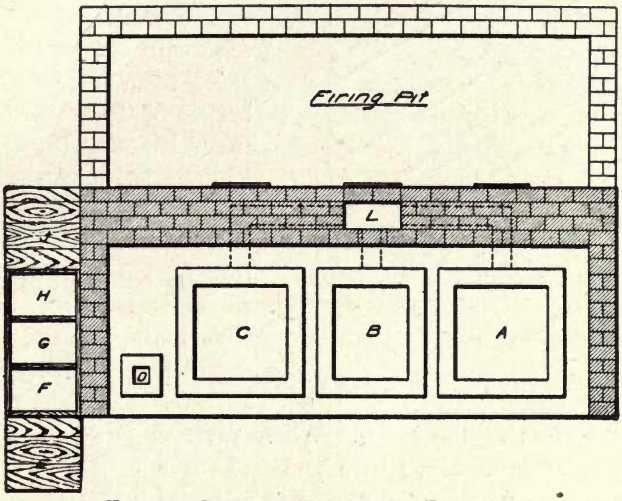

FIG. 49—PLAN OF RE-TINNING FURNACE

has another use; viz., that of preventing articles touching the sides of the kettle itself or sinking to the bottom and coming in contact with the refuse matter that has been removed from them in the process of "soaking." In this connection we will explain that whatever foreign substance is removed from articles subjected to the "soaking" process settles to the bottom of the kettle and in time becomes so hard that it is necessary to use considerable force to remove it. It often requires the use of a sharp bar to detach it from the kettle. The removal of this sediment is something that must be done at intervals of probably two or three weeks, although it may be found necessary on rare occasions to effect its removal at more frequent intervals.

There are certain classes of stamped ware that do not require being held apart in the soaking kettle by a device such as we illustrate by Fig. 50, for the reason that their construction effectually prevents them from "nesting" together tightly or in such

a way that the hot tallow in the soaking kettle could not readily effect the removal of whatever foreign matter has accumulated in the "stamping" or "spinning" process. The operator will readily understand that dishes with handles could not, owing to their construction, "nest" closely together. In such cases it is only necessary to use a rack or container that will effectually prevent the articles from settling to the bottom of the kettle or coming in contact with its sides. If the articles being treated do come in contact with the sides of the kettle they are apt to be burned, which might effectually prevent their taking the tin, or they might become badly fouled with the sediment by touching the bottom of the kettle. Where division racks in the container are not necessary, a wire basket of suitable size can be used. It is, of course, necessary to construct this wire basket or container in a way to obviate danger from the conditions just described.

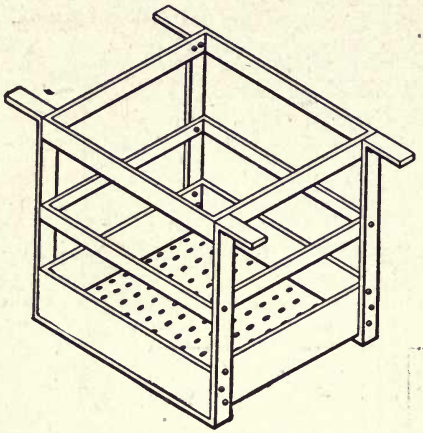

FIG. 50—RACK FOR TINNING SMALL WORK

We have described the intent and use of the soaking kettle at considerable length for the reason that on its proper use, or, perhaps we should say, upon the proper preparation of the articles in the soaking kettle, depends almost entirely the success of subsequent operations. As the soaking process proceeds the supply of tallow in the kettle decreases; hence, it is necessary to add fresh tallow from time to time as the work goes on, or as fast as it is lost by evaporation, or burned, it often being ignited from over-heating. It also often happens that the tallow will ignite when the racks are removed at the end of the day's work, and, owing to this constant danger of fire, the several kettles must be provided with tight covers, which constitute the most practicable way by which the flames can be smothered.

Where articles are being treated that require the use of racks or containers, a sufficient number should be used to insure constant and rapid operation. As from four to five minutes' immersion in

the soaking kettle is required on work stamped from heavy sheets, a sufficient quantity of containing racks should be provided to insure uninterrupted operation; viz., enough so that the operator will always have a pan in the soaking kettle in proper condition for immersion in the tinning kettle. It, of course, necessarily follows that after the container is once filled the operator replaces articles as fast as removed with others.

The kettle designated as B is for containing the molten tin in which the work is immersed after it has been prepared in the soaking kettle A. The method commonly used is to have the man operating the soaking kettle pass the articles as fast as they are prepared over to the operator at the tinning kettle; using for the purpose a pair of tongs of proper construction, or, perhaps we should say, of proper shape, meaning of a shape fitted to the article and one that will not have a tendency to bruise or break it. When the operator on the soaking kettle has removed an article from his kettle he immediately immerses it in the tin contained in the kettle B, drawing it up and leaving it on the surface of the tin to be handled by the tinner, who grasps it with suitable tongs and again immerses it in the tin, manipulating it rapidly and in such a way as to prevent, so far as possible, any dross or, as it is termed by tinners, "scruff" from attaching itself to the article being handled. At this point the skill and experience of the operator is exercised in keeping the tallow, which has been carried over from the soaking kettle, from attaching itself to the article being handled. We cannot very well describe the motions necessary to accomplish this object, as they can only be learned by experience. We wish to make it plain, however, that under no conditions must any of the grease from kettle A or B be allowed to be carried over into kettle C, as, in such a case, the contents of kettle C would be so badly contaminated that it would be impossible to produce good and satisfactory work. After the tinner who operates kettle B has accomplished the act of properly removing the article in hand from the tin kettle B he places it in kettle C, which has been provided with racks for the holding of such articles as racks are necessary for in kettle A. Even the proper transferring of articles from kettle B to kettle C requires no little amount of ingenuity and experience. The immersion of articles from kettle B into kettle C must be accomplished without rippling or disturbing the finishing tallow in ket-

tle C more than necessary, and the removal of articles from the finishing grease in kettle C must be accomplished in the same careful manner; viz., so as not to disturb or agitate the hot grease.

While it is essential that the tallow in the finishing kettle be kept clean and maintained at a uniformly proper heat, the best results are obtained after the tallow has been used for a time. In fact, satisfactory results cannot be obtained if the grease in this kettle contains too great a percentage of new tallow, or, as the operator would say, is too "sharp," meaning that if the tallow is too fresh and new the finished work will either be streaked or have the coating removed in places. As the object of this kettle is to remove all surplus tin possible, it will readily be seen that it is necessary to bail out the tin which accumulates in the bottom of the kettle at frequent intervals. In large plants this is usually done at the end of the day's work, at which time all the tallow in the kettles A and C is removed, principally to obviate the danger of its igniting through the night, at which time the fires are usually in charge of the watchman.

As each article is removed from kettle C the operator holds it in a position that will permit of what little surplus tin is left running to a given point, so as to permit its removal. This is accomplished by using a short rod of iron that is kept constantly immersed in the listing kettle. As soon as the drop has formed, and before it has time to harden, the operator takes the rod from the listing kettle in his left hand and draws it quickly and evenly over the place where the drop of tin has formed, much in the same way that a tinsmith would remove solder with his soldering copper. This explains the use of the listing kettle D. It is simply used for containing sufficient tin in a molten state for immersing the end of the listing rod, so that it will always be handy and in proper condition for removing the drops of tin as they form on the finished work.

The proper degrees of heat for the contents of the different kettles can only be determined by experience and practice. The tallow in the soaking kettle A must be maintained at very close to the heat of the molten tin in the tinning kettle B, and it is obvious that the tallow in the finishing kettle C must also be maintained at approximately the same temperature.

No more than two articles should be immersed in the finishing kettle at one time. If there are, one is almost sure to be spoiled.

As we have explained, this finishing kettle C is used for removing the surplus tin, and for this reason is called by tinners the "skinning" kettle.

In handling very large work the racks or containers are left out of the soaking kettle, and in their place a sheet of tin is dropped into the bottom of the kettle so as to keep the articles off the bottom. This sheet should be taken out at night.

As fast as the work receives the finishing touches from the man operating the finishing kettle, it is placed on racks and allowed to remain there until it is cool enough to be handled by the operators who give it the final finish. The finishing force for a re-tinning stack usually consists of three girls. For their use a long bench, E, Fig. 49, is provided. The first operator gives the work a thorough rubbing in dry soft sawdust contained in box F. The second goes through the same operation with swadust, mixed with what is known as "middlings" or wheat bran, and contained in box G, while the third performs the same operation with a cheap grade of flour, contained in box H. From there it is finished at the wiping bench J.

We will say, in a general way, that it is not necessary to immerse articles that are to be re-tinned in acid unless, by chance, they have become rusty through carelessness in some operation or by letting them stand too long after leaving the stamping machines. When it is necessary to remove rust by the use of acid, the articles must afterward be thoroughly rinsed in clean water, after which they should be dipped into boiling hot water and carefully and thoroughly dried by the use of sawdust.

In providing tongs for handling the work through the various kettles, only those made of steel should be used, and they should be carefully cleaned and coated with tin before being used. Care should be taken to select tongs suited to the variety of shapes being handled.

As dross forms in the tinning kettle very rapidly, it is necessary to take measures to prevent its interfering with the work. This is done by an operation known as "boiling" the tin, and is accomplished by forcing a large block of green wood, preferably white pine, to the bottom of the tinning kettle and causing it to remain there the desired time by some simple device adapted to the purpose, usually by means of a rod of iron inserted in a hole bored in the block. These blocks of green wood should be previ-

ously dipped in hot tallow; otherwise, they would cause the molten tin to spatter in all directions when the blocks were immersed.

In order to facilitate the removal of the kettles from the brick work when it is necessary to replace them for any purpose, and also to assist in the removal of the containers in the several kettles when it is desirable to remove them, a strong bar of iron should be built into the stack high enough to permit the use of a chain hoist. A few bars or rods of iron should also be built into the stack above the kettles, on which sheet iron can be laid to prevent the soot that gathers in the stack from falling into the kettles and thus spoiling the contents.

Fig. 48 is a sectional elevation of a re-tinning stack, and, as shown by Fig. 49, the kettles are fired on the opposite side from where the workmen stand when operating the kettles. In order to have easy access to the fires and to facilitate the removal of ashes, a pit is provided which should be large enough to attain its object. The depth of the pit is governed entirely by the depth of the kettles.

CHAPTER XVII

Tinning Gray Iron Castings

ONLY a few years ago all articles used in the preparation of food which were made of gray iron were zinc coated or galvanized, as they could not be tinned satisfactorily. This fact, and the fact that tin was a much more desirable metal than zinc for coating articles used for culinary purposes, was largely responsible for a method of tinning gray iron which was perfected by the author. To-day it is almost impossible to sell zinc-coated articles used in the preparation of food, as such articles made of gray iron are now tinned extensively. For example, ice cream freezers, lemon squeezers, meat cutters, bread and cake mixers, egg beaters, fruit stoners, vegetable cutters, etc., made wholly or in part of gray iron and tinned are now sold universally.

In addition to the uses to which tinned gray iron is put by the manufacturers of kitchen and other hardware specialties, it has been found of great advantage to give articles of cast iron that are to be copper or brass plated a coating of tin previous to plating them. The advantages come from the lessened quantity of material necessary to use in electroplating, the preventing of "leaking" or "sweating," so common where the plating is deposited directly on the bare casting, and also from giving the articles the appearance of spelter or brass castings.

By this process gray iron castings are prepared for tinning by rolling them in a solution of muriatic acid, sal ammoniac and water, the rolling barrel being constructed to retain, under pressure, the gas formed by the chemicals used. The use of this barrel makes it desirable to locate the tinning plant in a building by itself, as the gas generated is constantly escaping, carrying with it quantities of the solution. At the best the rolling room for gray iron tinning is a wet, dirty place, and the entire operation requires the use of considerable water.

Plant and Equipment

In erecting a building for this purpose particular attention should be paid to ventilation and drainage. A plan for constructing a

floor, with a view to perfect drainage, is shown by Fig. 43. Two or more kettles (depending on the nature of the work), set after the plan illustrated by Figs. 52, 53 and 54 and various tanks built after Fig. 24, complete the outfit. The arrangement of the outfit

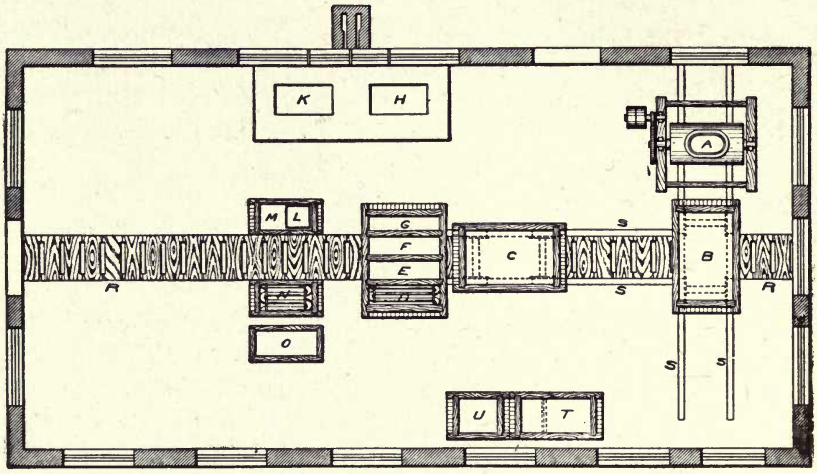

FIG. 51—ARRANGEMENT OF TINNING PLANT

is shown by Fig. 51, in which A is the rolling barrel for preparing the castings for tinning. B is a tank to receive the castings after they have been treated in the rolling barrel A. This tank should be provided with trucks, and a track should be laid so that the tank can be run under the rolling barrel to receive the prepared work. C is a water tank for storing the prepared castings after rolling, as hereafter described; D, E, F and G are divisions of one common tank; D is to contain an alkali solution, and should be provided with a steam coil, as shown, to heat the solution; E is a compartment for containing water for rinsing; F is to contain an acid solution; G is for the muriate of zinc; H is the roughing kettle of tin; K is the finishing kettle; L is the kerosene for cooling the work. The arrangement of this tank was explained in the chapter on

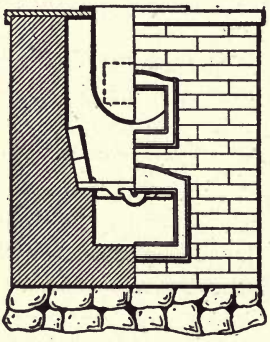

FIG. 52—FRONT ELEVATION

general tinning; M is a wooden tank large enough to accommodate the iron tank L and allow it to be surrounded with water; N is a tank for containing hot water, in which the

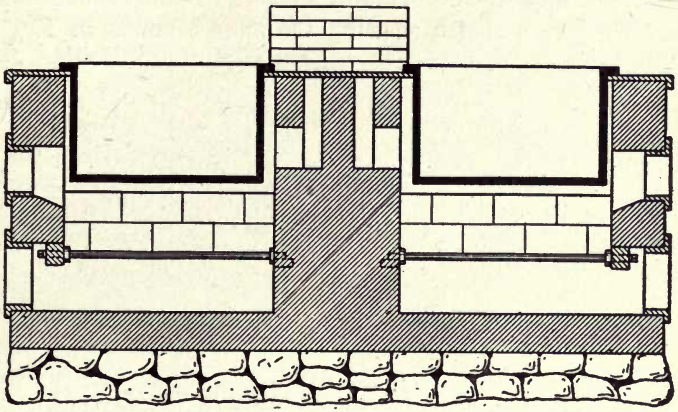

FIG. 53—SIDE ELEVATION OF TINNING FURNACE

tinned work is dipped to remove any traces of oil or acid, and is provided with a steam coil, as shown; O is a box to contain sawdust for drying off the work when it comes from the hot water

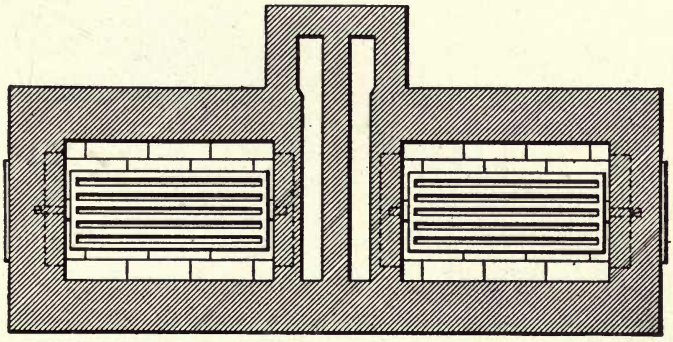

FIG. 54—PLAN OF TINNING FURNACE AT GRATE LINE

contained in the tank N; R R is a drain for carrying off the waste water, and S S are the tracks for moving the tanks B and C; T is a tank for containing a solution of hydrofluoric acid, used as hereafter described, and U is a storage tank. It is perhaps

needless to say that the ground plan may be changed to suit local conditions.

Only the most simple tools are required, which may be varied by the ingenuity of the operator to suit existing conditions of work. We give a sketch showing the most common in Fig. 25.

CHAPTER XVIII

Preparing Gray Iron Castings for Tinning

IN PREPARING gray iron castings to take a coating of tin there are several essential things to be taken into consideration; viz., the quality of the iron, the form of the castings, their condition when they come to the tinner and, if cored, the nature of the cores used.

Hard iron requires longer preparation than soft iron and a longer immersion in the molten tin. Castings made from patterns not designed with a view of avoiding sharp angles, and in which molding sand can easily find lodgment, are much more difficult to prepare than those made from patterns free from such hindrances. It is, of course, not always possible to do away with sharp angles in making patterns for castings that are designed to be tinned, but whenever possible they should be avoided in the interest of easy cleaning and perfect coating of the work.

Castings that have been freed from sand by the use of sulphuric acid require a special preparation before they will take a perfect coating of tin, and the use of this acid for this purpose should be avoided if possible. Cored castings made with cores in which rosin has been used must be treated differently from those made with an oil or glue core. For the intelligent understanding of the different conditions we give the specific course to be followed in each case.

The perfect coating of gray iron requires the use of two tinning kettles, and where castings are to be tinned previous to electroplating three kettles of tin should be used to insure the smoothest coating and the brightest luster.

Removing Sand from the Castings

The first operation in preparing the castings for tinning is to free them from sand. This is best accomplished by the use of the ordinary tumbling barrel, which gives the castings a smooth, clean surface while removing the sand. Where the castings are of a nature which prevents their perfect cleaning by tumbling, the sand should be removed by a solution of hydrofluoric acid and

water. Sulphuric acid will do the work, but in a much inferior manner and to the detriment of the castings as regards their easy and perfect coating in the tin. The reason for this is easily understood. Hydrofluoric acid acts directly on the sand, dissolving it rapidly without attacking the iron to any great extent. The action of sulphuric acid is just the reverse, the iron being dissolved on the surface of the casting, causing the sand to fall off, the sand itself not being affected.

Freeing Gray Iron Castings from Sand by Hydrofluoric Acid

While this operation is about the same as given for cleaning malleable iron by the use of this acid, we wish to impress the operator with the fact that in treating gray iron with acid of any kind, in preparing it for tinning, much more care must be exercised in the operation than with malleable iron, as the overpickling of gray iron leaves the surface soft and gummy, in which condition it will not take a coating of tin and it is no easy matter to put it in a condition where it will.

For quick cleaning of sandy castings by the use of hydrofluoric acid the preparation should be 1 of acid to 20 of water. For slow cleaning, which is necessary on castings having sharp angles into which the molding sand has burned, use the acid in the proportion of 1 of acid to 30 of water. The castings may remain in this solution until the sand is dissolved, after which, provided they have not been made with rosin cores, they are ready to be placed in the tumbling barrel used to prepare them for tinning. If rosin cores have been used the castings are to be treated in a special way, which will be explained in its turn.

A good arrangement for cleaning sandy castings with hydrofluoric acid is to have two tanks (oil barrels sawed in half will answer), one elevated above the other by means of a stand or bench, so that the top of the lower tank will be 3 or 4 inches below the bottom of the elevated tank. Bore a hole in the side of the upper tank close to the bottom and provide a plug. Place the castings in the upper tank and cover them with the hydrofluoric solution, which is contained in the tank below. When the castings have been completely freed from sand remove the plug and allow the solution to escape into the tank below, where it remains until required for use again. No specific rules can be given as to the time required to clean castings, and it is not necessary, as

an examination of the work from time to time while under treatment will determine when they are clean. Castings on which a light deposit of sand is attached may be clean after 15 minutes' immersion in the solution, while castings having a heavy coating of sand, or on which the sand has burned, may require 3 or 4 hours.

If the nature of the sand on the castings makes it seem probable that they will require a longer immersion in the acid, weaken the solution by the addition of water to a point where there can be no possible danger of the castings being affected in the way mentioned in the beginning of this subject.

Cleaning Sandy Castings with Sulphuric Acid

If sulphuric acid is used to free the castings from sand, place them on an inclined, raised, platform, which platform should be of a size to accommodate the intended production and arranged to allow the solution to flow back into a tank placed at the lowest point to receive it. Make the solution in the proportion of 1 of acid to 6 of water, and keep the castings wet with this solution until the sand can readily be removed by a stream of water. Gray iron castings cleaned in this way will have a soft, gummy surface, and will not take as perfect a coating of tin as castings cleaned by dry tumbling or by the use of hydrofluoric acid. They must be given a special treatment before tinning, which will be described in connection with the treatment of castings made with rosin cores and hard or greasy castings.

Cleaning Castings with the Sand Blast

In addition to the methods already described for preparing gray iron castings for tinning, the reader should not lose sight of the fact that the sand blast is a valuable agent for this purpose, and we strongly advise those who have sufficient work to warrant the installation of a sand blast plant to carefully investigate its possibilities. Special attention is given to this subject in Chapter VI, pages 51 to 65.

The Use of a Hot Alkali Bath in Certain Cases

After the castings have been freed from sand in some one of the ways described, provided they have not been over-pickled, or made with rosin cores, or greasy, and have not been faced with black lead facing, or picked with sulphuric acid, they are ready for tumbling in the solution of muriatic acid, sal ammoniac and

water. If any of these conditions should prevail, the castings must be given a treatment in a bath of hot caustic soda or soda ash.

If castings have been over-pickled—that is, left in the pickle until the surface has become covered with a soft, gummy substance—or if rosin cores have been used in making the castings or black lead facing used to give a smooth surface, or if grease or paint is present, they must be immersed for several minutes in a boiling solution of caustic soda or soda ash. Make the solution very strong, and see that the strength is maintained by adding fresh material as needed.

After this treatment the castings must be thoroughly washed with clean water before they are placed in the rolling barrel used to prepare them for tinning. D in Fig. 30 designates the tank to be used for the hot alkali solution and E, in the same illustration, is the tank used for rinsing.

Tumbling

Special care is required in preparing cast iron for tinning, in the tumbling barrel and a very comprehensive treatment of the subject is given in Chapter VI, pages 51 to 65. This material covers the construction, location, charging and operation of the barrel.

The important point to keep in mind in preparing cast iron for tinning is that the surface of the iron must be made perfectly clean. Not only free from sand and rust, but from every foreign substance. It may seem to the reader that we are dwelling on this point unnecessarily, but only by the most careful attention to the proper preparation of the castings, and in the keeping of them in the same clean condition until they receive the first coat of tin, can perfectly satisfactory work be obtained.

If the iron is allowed to roll in the solution too long a time the surface becomes soft from the action of the acid and the tin will not take. The same trouble will be experienced if the solution in the rolling barrel is too strong, or if the castings are allowed to remain in the solution too long after they are rolled.

Water Rolling

Where castings are tinned for the purpose of electroplating them, it is desirable, if an extra smooth surface is desired, to give them a rolling in gravel and water in the ordinary wet

rolling barrel, although this treatment is not necessary in order to prepare them to take a coating of tin. In treating castings in this way use a coarse hard gravel, and some castings may be rolled 20 to 30 hours to good advantage if the barrel is properly loaded.

CHAPTER XIX

Coating Gray Iron Castings with Tin

THE tin in the kettles being at the proper heat for the work in hand, as specified later on, the operator takes a small quantity of the castings from the storage tank C, Fig. 51, and places them in the wire basket designated A in Fig. 25, taking care to place those having concave sides, holes or depressions so that none of the various solutions, through which they are now to pass, will be retained. The castings contained in the basket must now be immersed in the solution of caustic soda or potash, which is contained in tank D, Fig. 51. This solution must be kept at the boiling point, and from 1 to 2 minutes is sufficient time to leave the castings in. The best plan for heating this solution is to have a steam coil in the bottom of the tank, as shown in the illustration, and to allow the exhaust steam to pass into the rinsing tank, which is placed beside it, as shown in the ground plan. The rinsing tank is designated E in Fig. 51. After the basket of castings has stood in the alkali bath contained in tank D for the desired time it is placed in the rinsing tank E until all traces of that solution are removed. This will take but a fraction of a minute, provided a stream of clean water is kept flowing into the tank, as it should be. In rinsing the castings in tank E do not allow them to remain in the tank for any great length of time if water is flowing in, as iron will soon rust in running water.

The next move is to immerse the basket of castings in a very weak solution of muriatic acid and water, 1 part acid to 40 of water. The tank for containing this solution is designated F in Fig. 51, and the castings must not be allowed to remain in it more than 2 or 3 seconds. The solution should be made up fresh after 2 or 3 tons of iron have passed through it.

Next, place the basket of castings in the tank G, Fig. 51, which contains muriate of zinc, to which has been added 5 pounds of gray granulated sal ammoniac for every gallon of the liquid. Muriate of zinc is made by dissolving zinc in muriatic acid, allow-

ing the acid to dissolve all the zinc it will. An earthen crock or a cleaned oil barrel can be used to make this cut acid in. This solution should be deep enough to cover the castings contained in the wire basket used for immersing them in the roughing kettle, and should be kept in good condition—that is, care should be taken to prevent its being weakened to any great extent by passing the solution in tank F into it with the work. The tank for containing this muriate of zinc should be lead lined, and an inner lining of wood used to protect the lead.

The basket of castings is now ready to be immersed in the molten tin contained in the first, or roughing, kettle, and shown in Fig. 51 at H The tin in this kettle should attain a heat of 500 degrees F., and this heat should be maintained during the time the kettle is in use.

Before immersing the castings in this kettle the surface of the tin should be covered by a flux, made by boiling a quantity of the muriate of zinc on top of the molten tin, and adding quickly to the boiling mass a quantity of white granulated sal ammoniac. The sal ammoniac must be added by sprinkling it on before the acid is evaporated by the heat of the tin. It will take a little time and experience before the proper consistency of this flux can be attained The proper making of this flux is one of the most essential points in the successful coating of cast iron in this first kettle of tin. If the flux is allowed to become hard and dry, as it soon will by continued use unless careful and constant attention is given to it, the flux will adhere to the castings as they pass through it into the tin below, and thereby prevent them from coating.

When it is found that the flux is becoming thick and lumpy, add a sufficient quantity of muriate of zinc and powdered sal ammoniac to cause the flux to boil up to a depth of ½ inch or more. When this result is obtained take a perforated iron skimmer and carefully remove any hard lumps and congealed matter remaining in the flux, allowing such as readily pass through the skimmer to remain in the kettle. The purpose of this flux is to prevent the surface of the tin from becoming oxidized by exposure to the air, and also to prevent the hot metal from spattering and burning the operator when the wet castings come in contact with the tin. Bear carefully in mind that this flux must at all times be kept in a thin liquid condition, otherwise the succeeding opera-

tions through which the castings are to pass before they are completed will be unsuccessful.

In forcing the castings into the roughing kettle, care should be taken to get them immersed as soon as possible. If they are allowed to float on the surface of the tin the muriate of zinc, with which they are wet (for the purpose of causing the tin to adhere), will dry off, and the tin will not adhere to the part of the casting thus exposed. The castings must be kept below the surface of the tin until they have become as hot as the tin itself, and until the tin has ceased to bubble or to be agitated by the castings that are immersed. This boiling or agitation will cease when the air and moisture is expelled from the iron and the flux, that adhered to it as it passed through, has risen to the surface of the tin.

The proper way to immerse the work in this first kettle of tin is to rest the handle of the basket containing it on a block of iron placed on the edge of the tin kettle, elevating the basket at an angle that will prevent it touching the molten tin until the operator is ready to have it. Cant the basket so that one of the lower edges will enter the tin first; in other words, do not allow the flat bottom of the basket to come directly onto the surface of the tin, as the effect of having as much wet metal as the bottom of the basket presents coming in contact with the molten tin will be an explosion, resulting, perhaps, in the serious injury of the operator or some one standing near. When the basket is in the described position, lower it carefully until 1 inch or 2 inches of the bottom and one side is immersed in the tin, then lower rapidly, but steadily, until the basket and its contents are completely immersed.

At this point turn the basket completely over, bottom up, and, using the edge of the tin kettle as a rest for the handle, lift the basket from the tin when it is free. Turn it bottom down and use it in that position to keep the castings it contained below the surface of the tin until they reach the heat of the metal. Fill the kettle with as many castings as it will hold and allow them to be completely immersed. Several of the wire baskets may be employed to insure having a batch always ready to immerse when a previous one has been disposed of.

It sometimes happens that the operator carelessly omits dipping the work in the cut acid contained in tank G, Fig. 51; that

is, he may attempt to immerse the work in the molten tin directly from tank D, E or F. Such neglect is dangerous and likely to be attended with serious results to the operator, due to spattering of the hot metal.

There are many kinds of castings that may be strung on wires and handled through the different stages without the use of wire baskets. When wires are used the shape may be varied to suit conditions. While we show the most common in Fig. 25, the ingenuity of the operator must be employed in selecting and devising those best adapted to his wants.

The kettle being filled, as described, the castings must now remain where they are for from 5 to 15 minutes, or until they have taken a perfect coating of tin. If, in this time, they are not properly coated, some error has been made in the previous operations and the work must be re-rolled.

What dross or slag forms in a tin kettle rises to the surface. A considerable part of this objectionable matter will be found in the first kettle, and must be removed before the work can be carried to the finishing kettle or kettles. To accomplish the removal of this dross, or slag, floating on the surface of the tin, use a perforated, concaved iron skimmer. The holes in the skimmer should be large enough to allow the clear tin to flow through freely, and care should be taken not to waste the flux in skimming out the dross. If the skimmer is canted edgewise the dross will adhere to the skimmer, while the flux and clear tin will flow back into the kettle.

When all the dross has been removed from the kettle, grasp one of the castings with a pair of tongs and remove it with a quick motion from the tin. If wires have been employed for stringing the work, take one or more wires and remove in the same way to the next kettle, taking care that no flux or dross is carried along with the work. The temperature of the tin in the first kettle is much too high for finishing work, and when the castings taken from it are exposed to the air they will turn more or less yellow, depending on the heat of the tin. A bright yellow or golden color indicates too high a heat and must be avoided. A slight yellowish tinge indicates the proper heat.

The tin in the second kettle, which is designated in Fig. 51 as K, and which, in most cases, is the finishing kettle, must be maintained at a temperature of about 400 degrees F., and the surface

must be kept covered to the depth of from ½ to 1 inch with pure beef tallow. Palm oil may be introduced into the tallow with good results, using about 10% palm oil. The operator keeps the castings held by the tongs or wires immersed in this second kettle 1 or 2 seconds and then, with the tongs held in the left hand, he removes the piece from the tin. As soon as the piece is clear of the tin the operator grasps it with another pair of tongs held in the right hand and, after a few rapid swinging motions to free the article from surplus tin, plunges it into the tank containing kerosene oil. If wires are being used he swings the work to and fro rapidly to free it from the surplus tin, and when plunging it into the oil he must give the work a motion calculated to prevent the articles in contact from adhering to each other.

The tank, which is designated in Fig. 51 as L, should be of sheet iron and placed in the companion tank M with the idea of having running water surrounding it to keep the kerosene from becoming over-heated, as it soon would be from having hot castings continually immersed in it. The work must be immersed in this oil long enough to set the tin and then immersed in the cold water contained in the companion tank M.

If the tin in the finishing kettle is at the right temperature the work will be white and have a nice luster after it is cooled. If the work is rough and lumpy it indicates that the tin in the finishing kettle was not hot enough or that the work was kept in the air too long a time before dipping it in the kerosene. The tin in the finishing kettle requires very little fire to be maintained, as there will be nearly enough heat in the castings brought from the first kettle to keep the tin in the second at a proper heat. If the work is yellow after cooling in the oil it may indicate too high a heat in the finishing kettle, or it may indicate that the casting was not kept in the finishing kettle long enough to bring the heat that the casting attained in the first kettle down to a point where the tin would not turn yellow.

Work can be taken from the finishing kettle smoothly and brightly coated even when the temperature of that kettle is so low that if a piece of cold iron be put into it the tin would adhere to the iron in a thick mass. The heat the castings attain in the first kettle makes it possible to run the finishing kettle at a very low temperature, and it is advisable to do so on very heavy castings. Light castings require that a much higher heat be

maintained in the finishing kettle than is necessary for heavy castings. The reason is apparent: All castings must be exposed to the air a few seconds while the operator is switching off the surplus tin. If the castings are light and the tin is cold they will not hold the heat long enough to allow the surplus tin to be shaken off without leaving rough, ragged edges.

A great deal of ingenuity can be displayed by the operator in the handling of castings of various shapes in such a way that no lumps or bunches of tin will remain on the work after it is cooled. For example, care should be used to ascertain what part of a casting is best adapted to be taken hold of by the cooling tongs without leaving marks of the tongs after the article is cooled. The tongs used for cooling should never be put into the tin kettle, as the heat of the casting would cause it to adhere to the tongs if they were tinned. After shaking off the surplus tin, change the position of the casting so that the drop of tin, which will naturally collect at the lowest point, will flow back into the coating on the casting, and dip it in the oil at once when this is accomplished.

A "switching box" should be employed, when "strung" work is being handled, to catch the tin that is thrown from the work in the operation of "switching" it to throw off the surplus metal. This box is a very simple affair. Its position, when in use, is designated D, Fig. 23. Cover the interior of the box with heavy paper, as the hot tin will stick to the wood unless paper is used. The tin thus collected may be thrown into the kettle with the paper when the tin is needed for use.

When the castings have been cooled, as already described, they should be immersed in a tank of boiling water to free them from oil and also to remove any trace of acid that may be on them. This final rinsing tank is designated N in Fig. 51. The water must be kept clean and at the boiling point at all times when in use. An ordinary foundry riddle, with upright handles long enough to allow the operator to set the riddle containing the work to be rinsed into the tank without scalding his hands, may be employed.

The castings should be dried off in clean dry sawdust, and that made from pine or some soft wood is best, as hard wood sawdust will scratch the tinned surface. The drying box is shown at O in Fig. 51.

When three kettles of tin are employed, as they may be to good advantage in tinning work that is designed to be plated, the second kettle must be run at a temperature of 450 degrees F. The surface of the tin in this kettle must be kept covered with an acid and sal ammoniac flux the same as the first kettle. The castings in the first kettle are passed in quantities to the second kettle, there to remain until the first kettle is refilled. As when using two kettles, care must be taken to prevent any of the slag or flux that accumulates on the first kettle from passing with the work into the second kettle, and the tin in the second kettle must be kept free from slag.

The tin in the third or finishing kettle should be maintained at a temperature of 400 degrees F., and the depth of the tallow increased to 3 or 4 inches.

If three kettles are employed they should be square or round, and arranged to fire from one side instead of from the ends.

As it is almost impossible to satisfactorily tin castings which have been imperfectly coated at the first attempt, the operator should give careful attention to details.

It is comparatively easy, with practice, to keep the tin at a proper heat, but the beginner will find more difficulty in doing this than any other one thing in the entire operation. That the proper heat be maintained is very essential, for if it is not all previous care in preparing the work will have been in vain. If too hot the flux on the roughing kettle will evaporate or burn off, and the tin will not coat the iron. If too high a heat is reached on the finishing kettle the tallow will be set on fire. As a help to the novice and, in fact, to the experienced man, we recommend the use of pyrometers; one for each kettle. The expense of providing them is not to be considered in comparison with the advantages obtained by their use.

The kettles for containing the tin usually are made of cast iron, although fire box steel is often employed to make oblong kettles.

A floor space of 20 x 40 feet will accommodate a tinning plant having two rolling barrels. If possible, the plant should be located handy to power and with a view to obtaining easy and perfect drainage. If necessity compels locating the plant in a factory building above the ground floor, as is sometimes the case, the

floor of the tinning and rolling rooms must be so constructed that leakage into the room or rooms below will be impossible.

The dross or slag formed in the kettles should be stored away until a sufficient amount has accumulated to make profitable the remelting of it to reclaim what pure tin is in it. For the purpose of remelting this dross the pure tin can be removed from the kettle H, Fig. 51, and the dross melted up in it. When the entire mass is in a molten state, and at a temperature of about 550 degrees F., bail off the good tin into cast iron pans provided for the purpose, and the dross which remains into separate pans. This tin dross has a market value of from 40 to 50% of the price of pig tin.

With the addition of tanks for containing cleaning acids, a plant built to tin cast iron is adapted to all descriptions of tinning, except re-tinning of tinware and the tinning of sheets.

CHAPTER XX

Cleaning Old Galvanized and Tinned Work

GALVANIZED material becomes dark or discolored from age or exposure and from various other causes. Galvanized sheet iron is often found to be covered with a white deposit, which discolors them even when the stock has been kept under cover, and it is almost sure to be found if it has been subjected to changes of temperature which have caused moisture to gather on the sheets. On galvanized castings the discoloration is seen in the form of a white powder which forms on their surface, or, if they have been stored in a room not subjected to marked variations of temperature, their surface simply turns dark.

While it is practically impossible to prevent this discoloration, and while it is not particularly detrimental to the wearing qualities of the coating, it is often detrimental to the sale of the material, as few care to buy goods that have a "shop-worn" appearance. The appearance of discolored material may be materially improved, however, and sometimes made to look like new, by dipping it in a cold solution of one part sulphuric acid to ten parts water. The material should not be left in the acid dip more than two minutes at the most, and as much less as possible, and accomplish the desired result. Neither should the material be subjected to frequent dippings, as it will become permanently stained by so doing. As soon as the material has been removed from the acid solution, it should be immediately rinsed thoroughly in clean, cold water, after which it should be immersed in a bath of boiling hot water, and carefully dried off in dry sawdust.

Cleaning Old Tinned Work

Tinned work that has been subjected to considerable handling, or that has been machined, will invariably lose its luster. While the original luster cannot be completely restored, the appearance can be improved by dipping the material in a hot solution of sal-soda. Make the solution rather weak; a pound of sal-soda to a gallon of water will usually be found strong enough for ordinary

purposes, and a weaker solution should be used if it will accomplish the desired result. As soon as the work is removed from the sal-soda solution it should be carefully and thoroughly rinsed in clean, cold water, and then immersed in clean, boiling water, after which it should be dried off and rubbed in dry pine sawdust, to which a little flour has been added. If dry sawdust is not available ordinary bran will answer the purpose very well, provided all moisture on the work has been allowed to evaporate before the bran is used.

It will be observed by referring to Fig. 48 that the kettles are heated on the sides, as well as on the bottoms, which is accomplished by means of spiral flues designated as K: these spiral flues having an outlet into the large flue L, shown in Fig. 49, and which is a separate flue from the one designed to carry off the fumes and smoke rising from the kettles.

CHAPTER XXI

Electro-Galvanizing Plant and Equipment

THE art of electro-galvanizing and its industry is not the result of an invention, but was simply created within the last twenty years by force of necessity in protecting such articles like springs, small wire netting, screws, bolts, nuts, etc., which could not up to that day be satisfactorily galvanized by the hot process, and this shows clearly that the creation of the electro-galvanizing industry was not a matter of cost.

The cold galvanizing has its advantages, being suitable for treating a large number of different articles, especially goods that have been hardened and tempered and all kinds of machine parts with perforations and threads; also in the continuous processes for band iron, wire and the galvanizing of small articles, such as tacks, nails, etc., in bulk form.

The hot galvanizing cannot compete in the satisfactory production of these articles, and, on the contrary, the electro-galvanizing never will compete with the hot galvanizing on such articles as tanks, boilers, architectural iron and building material, etc.

One of the earliest records of electro-galvanizing is an English patent taken out by Charles Cleophas Person, on April 27, 1854, and reads as follows:

Coating with Zinc by Galvanization.

"The zincing is effected by electro-deposition from a bath containing salts of zinc and alumina. The solution may be prepared by dissolving precipitated alumina in a solution of sulphate of zinc, but the inventor prefers to dissolve oxide of zinc in a solution of crystalized alum. The zinc may be deposited from such a solution on all metals, viz.: iron, copper, platine, etc., and the adhesion is complete: if care is taken previously to make the surface of the article bright."

It is only within the past decade that any marked advance in the commercial use of electro-deposited zinc has been noted, and it is in the United States that the deposition of this metal, by means of a low-tension current, has reached its highest commercial development. While the knowledge that zinc could be readily

deposited has existed for a long number of years, the process was never taken up in a practical commercial way until about 1900. At that time attention was directed to the subject through experiments made by the governments of England, Germany and the United States, which demonstrated the efficiency of the electro deposit for certain classes of work. In line with the experiments which had been made, the United States Government established tests and installed small electro-galvanizing plants at various arsenals and shipyards throughout the country. Manufacturers of electro-plating materials availed themselves of the information brought to their attention, and during the past ten to twelve years the growth of this industry has been rapid and electro zincing or galvanizing is now being applied to many iron and steel articles which could not as readily be treated in any other way.

Equipment for Electro-Galvanizing Plant

An electro-galvanizing plant may be subdivided into two important departments—the cleaning department and the galvanizing department proper. In the cleaning department the equipment consists of:

1. Suitable tanks,
   a. For sulphuric or hydrofluoric pickle,
   b. For hot potash,
   c. For electro-cleaning.
   d. For washing and scrubbing.
2. Tumbling barrels or sand blasting apparatus for cleaning small material.

The galvanizing equipment comprises:

1. Suitable tanks or automatic devices, including rinsing and drying apparatus.
2. Necessary galvanizing solution.
3. Copper conductors.
4. Anodes.
5. Low-voltage generator.
6. Switchboard consisting of voltmeter, ammeter and rheostat.
7. Hot-water tank.

This is the complete unit for a galvanizing plant with still tanks, and such equipment can be found in the plants of large

metal manufacturers and makers of specialties throughout the country. Such a plant does not require any further explanation. A rough layout is shown in Fig. 55.

Galvanizing is accomplished as an accessory to other electroplating activities or whole plants are devoted to galvanizing exclusively. Illustrations of the latter type are shown in Figs. 56 and

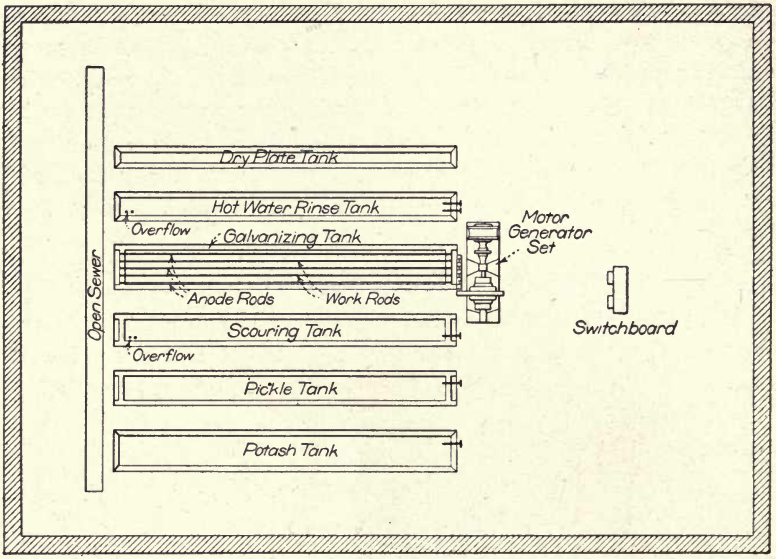

FIG. 55. FLOOR PLAN OF ELECTRO-GALVANIZING PLANT

57. Fig. 56 shows one of the most up-to-date electro-galvanizing departments in the world, possessing perfect light and ventilation and ample room for the operators to discharge their duties. The plant shown is that of the Spirella Company, Niagara Falls, N. Y., and is devoted to the protection of the wires of the Spirella Corset products. Fig. 57 shows a remarkable electrical installation, with 22 units supplying the current for the tanks shown in Fig. 56. At no point is the lead from the generator to the tank longer than 10 feet.

A special feature in this plant is the covering of the cyanide tanks with sliding hoods, as shown on the right in the foreground of Fig. 56. The fumes from these tanks are taken away from under the hood by an exhaust blower.

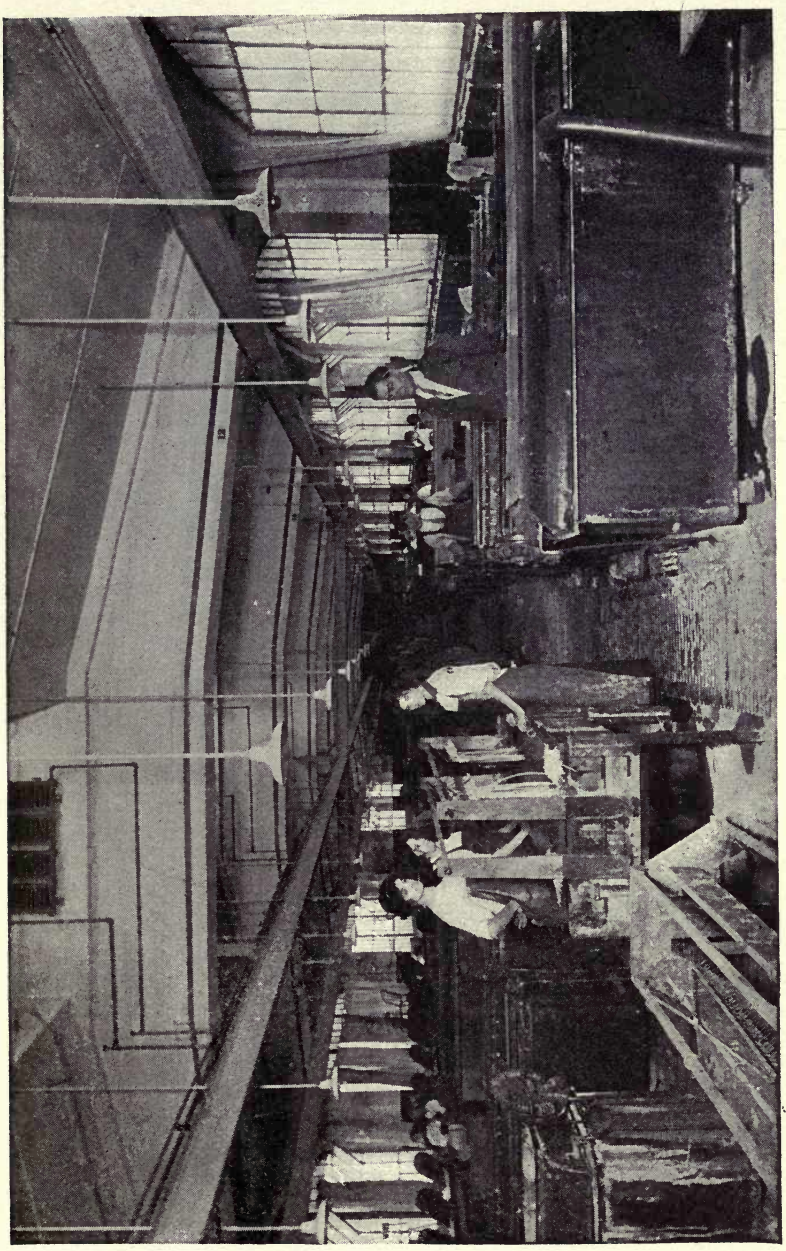

FIG. 56. THE MODEL PLATING ROOM OF THE SPIBELLA COMPANY

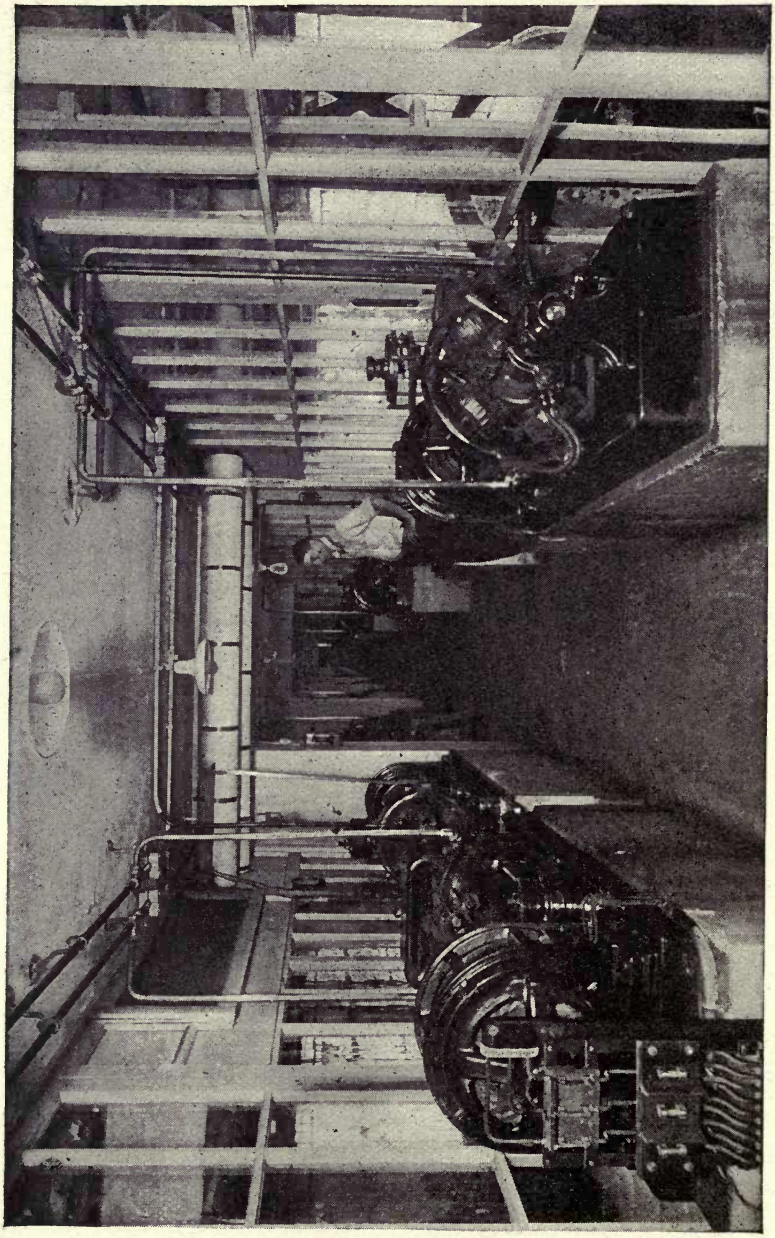

FIG. 57. REMARKABLE ELECTRICAL INSTALLATION IN PLANT OF SPIRELLA COMPANY

Mechanical Galvanizing and Patented Devices

The foregoing paragraphs have dealt in general with electro-galvanizing, and, as the mechanical electro-galvanizing, in other words, the zinc deposition in bulk quantities, has so much merit, it is worthy of special mention. The increasing use of mechanical devices for electro-deposition affords ample reason for an extended study of this juncture of the principles involved.

In the mechanical electrical deposition of zinc, there is a higher voltage and amperage used, and through this in a shorter length of time more zinc is deposited than in still open tanks.

Still open tanks can also be made partly mechanical by agitating either the electrolyte or the goods to be plated. Some firms make it a practice to move the bus bar either horizontally or perpendicularly, or the electrolyte is agitated by blowing air through perforated lead or rubber tubes from the bottom of the tanks, or by agitating the solution through a floating-tank system or by the means of a propeller.

The above refers to all kinds of articles, especially such work which cannot be successfully plated in tumbling machinery and which has to be specially suspended on wires, hooks or racks. Also for this class of work various kinds of new machines and devices have been adopted to reduce the labor cost and shorten the time of plating.

The Miller Chain Conveyer Machine

Illustration 58 shows such an apparatus, patented by C. G. Miller, of the Meaker Company of Chicago. This machine carries the goods by means of a chain conveyer through the electrolyte. The chain conveyer is adjusted in a perpendicular position and as soon as one article is ready and thoroughly plated another one is suspended on the same hook, making the process a continuous one.

A indicates a tank conveniently constructed of wood, though, obviously, it may be lined with any suitable material. As shown, at the rear or discharge end of said tank is provided an upright frame composed of posts *a—a'*, two on each side, and which may be transversely connected in any suitable manner to afford rigidity and strength, and journaled upon the uprights *a'*, which are at the rear end of the tank, is a shaft B, provided on its outer end with a worm gear *b*, adapted to be driven by means of a worm

b^1, on a shaft b^2, provided with tight and loose-belt pulleys b^3—b^4, as is usual.

Journaled upon a standard C, at the forward end of the tank, is a transverse shaft C^1, provided centrally with a sprocket wheel c thereon. Journaled on adjustable pulley blocks D, of any suitable kind, secured on the rear end of the tank on each side thereof is a shaft D^1, corresponding with the shaft C^1, and parallel thereto

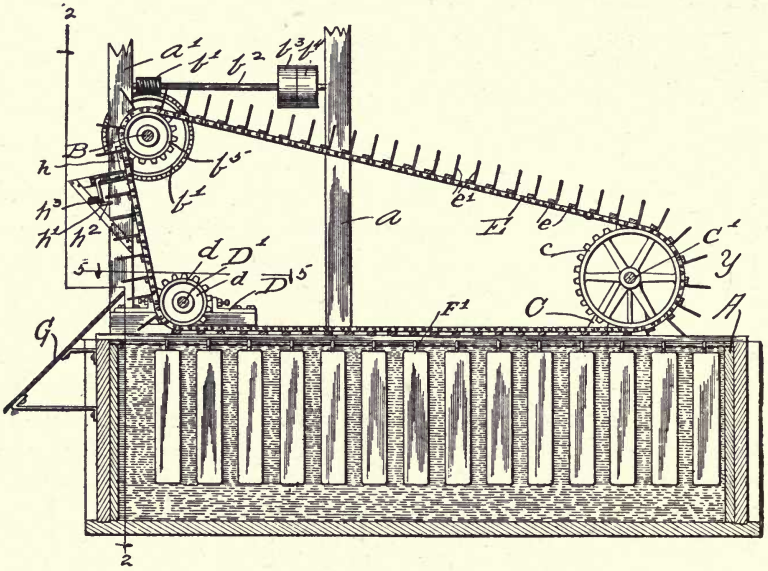

FIG. 58. VERTICAL SECTION OF THE MILLER CHAIN CONVEYER MACHINE

and provided with a sprocket d centrally thereon and in alignment with the sprocket wheel c on the shaft C^1 A corresponding sprocket wheel b^5 is provided on the shaft B, above the shaft D^1, and trained about said sprocket wheels is a sprocket or link-belt chain E, of any suitable kind or construction, adapted to be run on said sprocket wheels.

As shown, the diameter of the sprocket wheels c—d is such that the lower run of the sprocket chain E is parallel with the top of the tank, and, of course, with the electrolyte in the tank, and secured transversely on said chain at short intervals apart are metallic bars e, which are engaged to the appropriate links of said chain near the middle of each bar. Engaged near each end of each of

said bars is a downwardly directed hooked wire or rod e^1, the lower end of which is directed laterally and outwardly toward the wall of the tank, and serve as hooks to support the articles to be plated or coated.

Extending longitudinally the tank near each of the side walls and at the middle of the same are conductors f—f^1—f^2, which, as shown, are round metallic rods connected with one of the leads f^3, from the generator F, on which are suspended the anodes F^1, which hang downwardly in the electrolyte in parallel relation with each other and, of course, may be of any desired number, and afford a sufficient surface for the purpose required. Said conductors are connected by a cable f^4 with each other at one end of the tank. As shown, the central, parallel bus bars f^5 are provided on each side the central conductor F^1, and, as shown, are flat bars of metal, which are supported upon the top of the tank and projecting above the same, and on which the flat bars e on the chain slide, and which thus serve to support the lower run of the chain and its load during the plating operation. Said bus bars are connected with the other lead f^6 of the generator.

As shown, the shaft D^1, with its sprocket wheel d thereon, is arranged forwardly of the upper shaft B, and its sprocket wheel, thus inclining the upward run of the chain outwardly over the discharge end of the tank and, as shown, an inclined chute board G, is supported upon suitable brackets on the discharge end of the tank, and its upper end projects to near the extended ends of the hooks e^1, as they rise from the electrolyte, and is adapted to receive the articles discharged from said hooks to direct the same from the tank.

Means are provided for jarring the chain to shake the articles more or less during the plating or coating operation, and also to remove the coated articles from the hooks. For this purpose, as shown, a short shaft is journaled in suitable bearings on the inner face of each of the uprights a^1 and the ends h—h^1 of which are directed oppositely to provide arms. The arm h is curved to provide a cam, as shown more clearly in Fig. 58, and is adapted to be engaged by the end of each bar e, to adjust the other arm h^1, to engage within the hook e^1. Said arm h^1 is provided with a hooked end h^2, and a spring h^3 is secured at its ends to the arm and bar and acts to throw the hook h^2 outwardly when the bar e passes the cam h, thereby removing the articles from the hooks e^1.

Operation of the Miller Machine

The operation is as follows: An operator stands at the receiving end Y of the tank and, as the chain travels downwardly toward the tank the current passes therethrough into the bus bars, thus hooks. This is, of course, easily accomplished if the articles are apertured. If not, wire loops may be provided whereby the article may be engaged upon the hook. The chain is thus loaded progressively, and as the articles are submerged in the electrolyte within the tank the current passes there through into the bus bars, thus completing the circuit. Obviously, a very large surface of the metal to be plated is exposed between the anodes supported vertically in the tank, and as the articles to be plated travel longitudinally in the tank between the same the thickness of the coating may be regulated by the rate of travel and, of course, the current. Having passed through the tank, said articles are raised from the electrolyte upon the upward run of the chain and as the same approach the hooked jar arms h—h^1 these, as the successive bars e engage the arm h, the arms h^1 swing inwardly, after which the springs retract the arms h^1 for their hooked ends to remove the articles from the carrying hooks, adapting the articles to fall upon the chute G. Owing to the quick retraction caused by the spring, the arm h of the jar mechanism is thrown inwardly to engage the succeeding bar e, which jars the supporting mechanism and particularly the lower run of the chain gently, thus tending to constantly shift the contact surface on the hook of the article being coated. In this manner, uniformity of the coating is assured.

In use, the outer end of the supporting hook becomes slightly enlarged by the deposition thereon of the plating metal. This assists in holding the articles (while coating) on said hooks, and, in consequence, there is little or no tendency of the same to fall therefrom to the bottom of the tank.

Of course, other means may be provided for releasing the plated or coated articles from the supporting hooks, the jar arms, however, acting simultaneously and oppositely, are very effective and are automatic in operation.

Obviously, the lower run of the chain is at all times supported in horizontal position whatsoever the load thereon, by means of the bus bars. If the chain should at any time become slack, the adjustment may be quickly made by means of the adjustable bearings D for the shaft D^1.

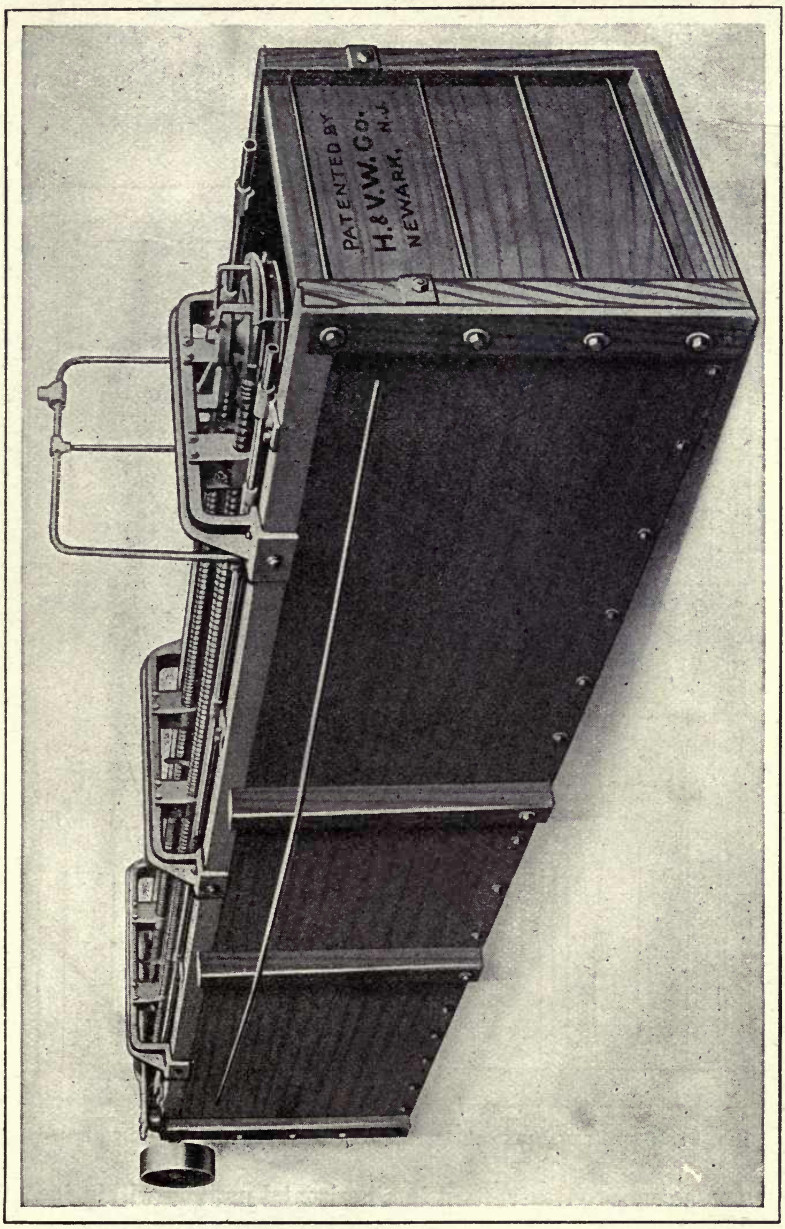

FIG. 59. DANIELS SCREW CONVEYER MACHINE

Daniels Screw Conveyer Machine

Figs. 59, 60 and 61 show a similar construction by which the goods should be first suspended on wires, hooks or racks and then

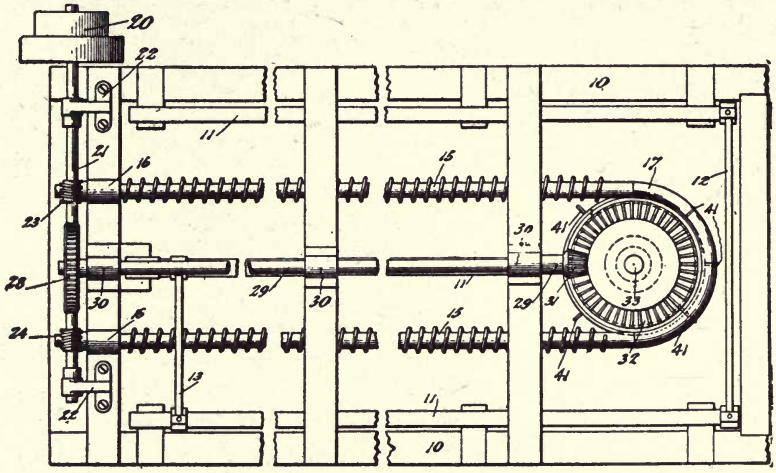

FIG. 60. TOP PLAN VIEW OF DANIELS SCREW CONVEYER MACHINE

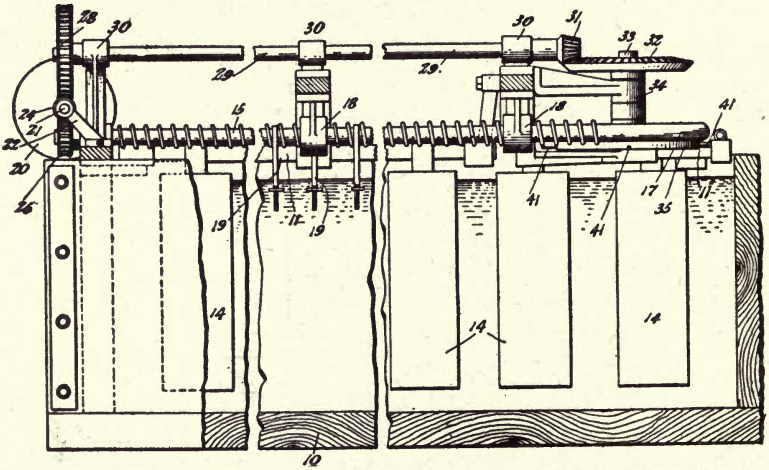

FIG. 61. SIDE ELEVATION OF DANIELS SCREW CONVEYER MACHINE

hung on a screw conveyer, fixed in a horizontal position within the tank above the solution. This device has been patented by the Hanson & Van Winkle Company of Newark, N. J.

In apparatus herein shown 10 indicates the vat for containing the bath, and 11 the longitudinal anode rods inter-connected by transverse conductors 12 and 13. In the present embodiment of the invention 3 anode rods 11, comprising two outer and one intermediate, are shown. The anodes 14 are hung on the anode rods 11, thereby subdividing the entire bath into two longitudinally extending lanes or spaces, through which successively it is designed to convey the articles to be plated. The number of lanes or spaces thus formed may of course be varied to suit requirements, by corresponding variations in the construction of the apparatus, but the construction and arrangement herein shown will be sufficient to illustrate the invention.

For conveying the articles through the spaces to either side of the inner line of anode rods conveyer screws 15 are provided. These extend longitudinally of the vat and are disposed above the level of the bath, one on either side of the intermediate line of anode plates. The conveyer screws 15 may be constructed in any desired manner, but as shown herein they are constructed of rods or shafts, on which are disposed conveyer coils. The conveyer screws are journaled at one end in suitable bearings 16, and at the other end on a stationary curved rod 17, as will be clearly shown. Intermediate of their two ends the rods are supported at suitable intervals by the intermediate supports or bearings 18, which as illustrated in Figs. 60 and 61 are bifurcated to permit the passage of the cathode hangers 19, as clearly shown.

To drive the two conveyer screws in opposite directions power is applied to belt pulley 20 fixed on shaft 21 suitably journaled in bearings 22 and carrying worm sections 23 and 24 of opposite pitch, which mesh with worm gears 25 and 26, respectively, of the two conveyer screws. A worm section 27 is also provided on shaft 21 which operates a worm gear 28 fixed on longitudinal shaft 29 journaled in bearing 30. The other end of shaft 29 carries a bevel gear 31, which meshes with the bevel bear 32 fixed on a vertical shaft 33, which is journaled in a bearing 34 suitably mounted on the framework of the apparatus. Vertical shaft 33 has secured to it, as illustrated more clearly in Fig. 61, a transfer disk or wheel 35, which runs on roller bearings 36 mounted in a supporting arm 37 of the framework. The supporting arm 37 provides a bearing or guide for the lower end of

vertical shaft 33 as shown. The transfer disk or wheel 35 is herein shown as having its periphery formed with an annular concave surface, conforming in radius with the stationary curved rod 17 above referred to, whereby the curved rod receives support. The curved rod serves as a transfer rod or support while the cathode hangers are being transferred from one conveyer screw to another, as will be shown. The two ends of the transfer rod thus constituted are reduced and provided with annular peripheral grooves 38, forming ball races for ball bearings 39, and a pin race for the key pin 40. The adjacent ends of the conveyer screws 15 are bored to fit over the reduced ends of the transfer rod 17, as clearly shown in Fig. 61, so as to bear on the ball bearings 39. The key pin 40 above referred to is inserted through a perforation near the end of the conveyer screw, whereby the transfer rod is retained in position upon the transfer disk 35.

Transfer disk 35 carries a series of radial fingers 41 which project outwardly from its periphery in a plane beneath the plane of the coils of the conveyer screws, which coils terminate within the vertical circumferential plane of fingers 41, but not in the path of the fingers.

Operation of Daniel's Screw Conveyer Machine

The operation of the apparatus will now be apparent. The cathode hangers bearing the articles to be plated are hung upon the conveyer screws 15 at suitable intervals while the screws are rotating, and the hanger thus progresses on one of the conveyer screws toward the transfer rod 17, passes freely through the opening at the bottom of the intermediate supporting bearings 18, and when it arrives at the termination of the coil on the conveyer screw, it is engaged by one of the transfer fingers 41 of the rotary transfer disk 35. The hanger is thereby carried from the end of one conveyer screw onto the transfer rod 17 and finally delivered to the end of the other conveyer screw at a point where it will be engaged by the coil of the conveyer screw and started on its return through the bath. The negative terminal of the current is connected with the conveyer screws 15, so that the articles carried by the cathode hangers 19 become the cathode in the bath and are plated. The articles to be plated may be of such weight as to tend to distort the conveyer screws, but by the

provision of the intermediate supporting bearings such tendency is rendered ineffective.

In the apparatus shown and described the articles to be plated are introduced and removed from the same end of the vat and in order to maintain the cathode surface area substantially uniform in the electroplating operation, it is advisable to avoid variations in the number of the articles being plated. By the arrangement shown the maintenance of uniformity in this respect is facilitated as the operator standing at one end of the vat introduces a new article for each plated article withdrawn. The rheostat can, therefore, be adjusted in starting up operations to suit the particular requirements, but after the number of articles in the vat has reached full capacity no further regulation of the rheostat is necessary. The plating thus conducted is of highly uniform character and is independent of the judgment of the operator, as the conditions determining the character of the plating are mechanically controlled.

The Fleischer Cable or Chain Conveyer Machine

Figs. 62 to 65 show a cable or chain conveyer traveling over numerous rollers and so placed that goods suspended on knobs fastened to the cable will travel in a continuous motion from one tank into the other. First, cleaning; second, rinsing; third, plating, and, fourth, drying. This apparatus is patented by Herman & Charles Fleischer and assigned to the Stanley Works of New Britain, Conn.

1 is a water-tight tank of usual form, open at the top. The tank 1 receives and holds the plating solution. 2, 2 are anodes. 3, 3 are articles to be plated, which will hereinafter be termed the "cathodes." In the preferred form of our invention both the anodes and cathodes are mechanically conveyed into, through and out of said plating solution; but it is not absolutely essential to certain fundamental features of the invention that the cathodes themselves be moved through said solution.

4, 4 are bars, which we term "anode-carriers," the same being formed of suitable conducting material. Both ends of each of the anode-carriers 4 are connected to drive chains or belts 5, 5, arranged to traverse on opposite sides of the tank, each chain 5 traversing over a series of independent guide-sprockets arranged on opposite sides of the machine.

6, 6 are cathode-carriers, from which are suspended the cathodes 3, 3. Both ends of each cathode-carrier are attached to chains 7, 7, which are arranged to traverse the opposite sides of the tank and are guided by suitable independent sprockets, also located on opposite sides of the machine.

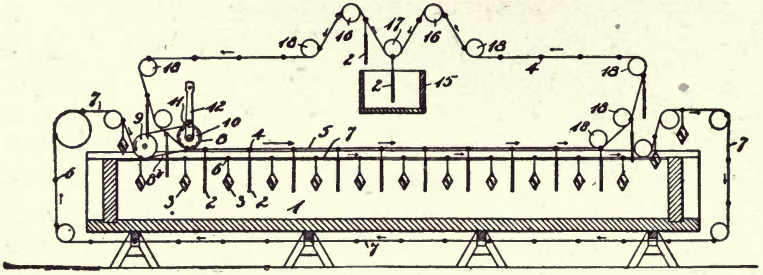

FIG. 62. SIDE ELEVATION OF FLEISCHER MACHINE

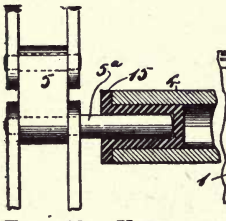

FIG. 63. VIEW OF FLEISCHER'S MACHINE SHOWING CARRIER AND CONVEYER CHAIN

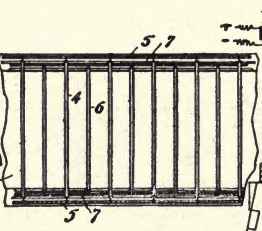

FIG. 64. CROSS SECTION OF TANK OF FLEISCHER CHAIN CONVEYER MACHINE

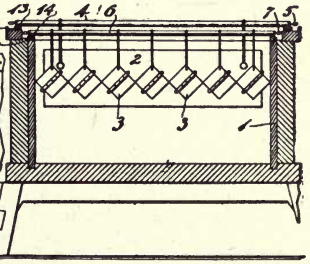

FIG. 65. ENLARGED DETAIL VIEW OF TANK SHOWING ANODES IN POSITION

The chains 5 and 7 are driven at a corresponding rate of speed. Any suitable driving means may be provided. For example, the guide-sprockets 8, 8 may be mounted upon a shaft 8ª, so that when rotary motion is imparted to one of said sprockets it will be transmitted through one shaft to the other sprocket. One of the sprockets 9, traversed by chain 7, may act as the drive-sprocket for one of the chains 7. The corresponding guide-sprocket on the other side of the machine (not shown) may be mounted on a shaft with the guide-sprocket 9, so that when one turns the other will turn. The driving-sprockets 8, 9 may be connected by means of a chain 8ᵇ, so that power applied to either of the sprockets 8 or 9 will be transmitted to the other. In the preferred construction the

sprockets 8, 9 are rotated intermittently by means of a ratchet 10, pawl 11 and rocking arm 12.

The anode-carriers 4 are spaced apart at equal intervals, and the cathode-carriers are spaced apart at like intervals. When the anodes and the cathodes are being conveyed through the solution in the tank 1 it is preferred that said anodes and cathodes be spaced apart alternately and at equal intervals.

13, 13 are tracks along the upper opposite edges of the tank 1 and arranged to support the anode-carriers 4 while the anodes are immersed in the solution in tank 1. 14, 14 are tracks also arranged along the edges of the tank 1, their function being to support the cathode-carriers 6 when the cathodes are immersed in the solution. To prevent interference, the tracks 14, 14 are preferably spaced apart a less width and are at a lower elevation than the tracks 13. The length of the cathode-carriers 6 is correspondingly less than the length of the anode-carriers 4. One or both of the tracks 13 constitutes electrical contact for the carrier 4. The same is true of one or both of the tracks 14, the same being an electrical contact for the cathode-carrier 6. The signs plus (+) and minus (—) represent the respective electrical connections. The track 13, being the anode connection, is positive, while the track 14, being the cathode connection, is negative.

The chains 5 and 7 are preferably insulated from the carriers 4 and 6.

15 is a bushing of insulating material provided at each end of the carriers. Pins 5^a, carried by the chain 5, project into these insulating-bushings 15.

The guide-sprockets over which the anode-chains 5 run are so arranged that the anodes will be lowered into the plating solution at one end of the tank, whereupon the anode-carrier will make electrical connection with the track 13. The anodes are then conveyed through the solution and removed from the other end of the tank. The guide-sprockets over which the cathode-chains 7 run are so arranged that the cathodes will be lowered into the solution alternately with the anodes, whereupon the cathode-carriers will make an electrical connection with the track 14. The cathodes are then conveyed through the plating solution and removed from the other end of the tank. While in the solution the cathodes and anodes are preferably spaced apart at equal intervals. While in the plating solution the surfaces of the anodes will become fouled

by a scum-like deposit, which if allowed to accumulate will impair the free plating action and dissolution of the metal. By making the anodes automatically removable they may be readily cleaned—for example, by causing them to be immersed in an anode-cleansing bath, which may be provided in tank 15. The guide-sprockets 16, 16, 17 are so arranged that each anode will be lifted up over the edges of the tank 15 and immersed for a short time in the cleansing solution therein. There are many advantages in keeping the anodes clean, among which are rapidity of dissolution of the metal, relatively rapid speed and uniformity of deposit, saving in electric current and chemicals. The balance of the guide-sprockets for the anode-chain not already numbered are indicated at 18, 18. Obviously the particular arrangement of the guide-sprockets and the method of supporting them is entirely immaterial.

The movement of the chains 5, 7 is so comparatively slow that an operator standing at either end of the tank may remove the plated articles from the cathode-carriers 6 and substitute unplated articles which in due course will be conveyed through the plating solution, as previously described.

By causing the articles to be passed through the solution alternately with the anodes, each line of articles suspended from a cathode-carrier is moving into a sphere of solution which has been enriched by the dissolution of the anode immediately in front of it, the said anode practically recharging the solution which has been partially impoverished by the cathode immediately preceding said anode.

While to those features of the invention already described it is not essential that the apparatus shall have the capacity of preparing the articles to receive the plating deposit, a further development of the invention contemplates the continuation of the cathode-chains 7, 7 so that they will cause the cathode-carriers 6, 6 and articles suspended therefrom to traverse a washing-tank 19, in which tank various baths may be provided in separate compartments, into which the articles to be plated may be successively immersed in order to prepare the surfaces thereof to receive the plating solution. We have found that great economies are attained by this arrangement. Not only is the danger of possible contamination of the surface of the article rendered practically impossible, because the articles are not manually handled after being cleaned and until they are plated, but a decided saving in

chemicals results. The chains 7 traverse in the direction of the arrows, so that an operator standing at the left-hand end of the tank may attach to the carriers mounted on the chain 7 the articles to be plated. These articles are conveyed into the several preparatory baths successively, and the movement is so comparatively slow that ample opportunity is given for the chemicals to drip from the articles into the baths from which they are removed before being immersed in another bath which may be, for example, of a different chemical nature. This drip occurs directly over the bath from which the article is removed, and hence the particular chemicals therein are saved.

The danger of injury to operatives by contact with the chemicals, incidental to the cleansing of the articles, is entirely eliminated.

20 is a final washing-tank at the opposite end of the plating-tank into which the plated articles are immersed after being removed from the plating solution.

21, 21 represent the sprockets for the chain 7 whereby said chain is moved in such a course that the cathode-carriers supported by said chain will be conveyed in such a direction as to move the articles to be plated over each of the partitions in the tanks 19 and 20, so that the said articles will be washed or immersed in the aforesaid baths. The particular arrangement of these sprockets 21 is, of course, immaterial so long as they permit of the use of endless bands or belts 7.

These foregoing illustrations show the different ways and means which can be adopted to improve the plating of larger articles in open-tank work.

The Daniels Plating Barrel

Figs. 66 to 69 show a plating barrel suspended on a shaft with a special connection carrier. The barrel is of the perforated type and is immersed entirely in the solution. Curved anodes have to be used to secure a better current conductively all around the barrel. The center shaft within the barrel is provided with chains to connect the work with the negative current of the dynamo. By loading and unloading the goods to be plated in this barrel, the barrel must be lifted from the solution and connections by means of a lifting device. This machine is patented by the Hanson & Van Winkle Company of Newark, N. J.

Fig. 68 is a longitudinal vertical section of one form of electro-

plating apparatus, and one form of revoluble container, drum or cylinder, mounted upon a shaft or spindle, said view illustrating in elevation, a number of flexible contacts or cathode-elements embodying the principles of this invention.

1 is the tank, comprising base 2, sides 3 and ends 4. 5 is one of the two usual and similar anode bars from which the anodes 5′ are suspended on either side of the drum or container 8. These bars 5 are secured to the tank by fasteners, as 6, and are con-

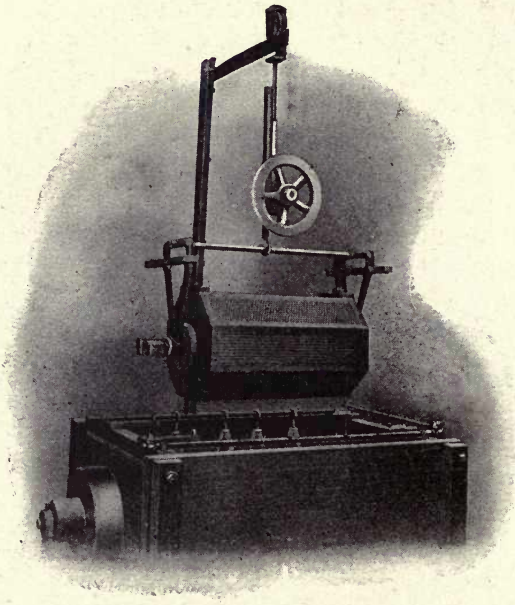

FIG. 66. HAND WHEEL LIFTING DEVICE FOR DANIELS BARREL

nected by means of the connector 7 with the wire 7′, which connects with the positive terminal of an electric generator.

The mass of articles 8′ is placed within drum 8, which is rigidly mounted on shaft 9, rotatable in bearings 11 of removable suspension frame 10 having members 12 removably engaging with and supported by rods 13 secured to and extending across tank 1, and through connector 13′ and wire 13″ connected with the negative terminal of an electric generator. Shaft 9 is driven from a shaft member 14 by any convenient power, a separate connection between said shaft and member being made, in this instance.

The novel cathode members, or elements, are loosely and movably combined with and supported by shaft 9, from which they depend. They comprise, in this instance, a weight or sinker-portion 19, a

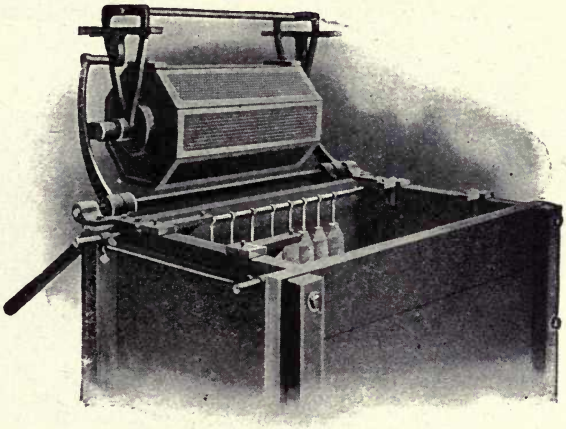

FIG. 67. LEVER LIFTING DEVICE FOR DANIELS BARREL

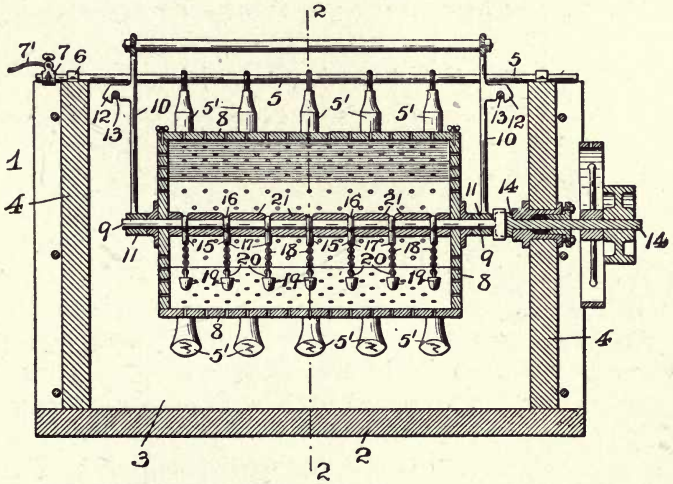

FIG. 68. VERTICAL SECTION OF DANIELS PLATING BARREL

coupling portion comprising ring, or eye, 16 loosely encircling shaft 9, and an intermediate flexible portion, in this instance a section of chain 18, the upper link of which is connected with an eye or

hook-shaped part 17 of a stem or rod 15, thereby loosely connecting 15 with 19 as shown.

During the rotation of the drum the articles to be electroplated are tumbled about within said drum, constantly exposing new surfaces, and making efficient contact with the weight or sinker-portion 19 of the cathode-member.

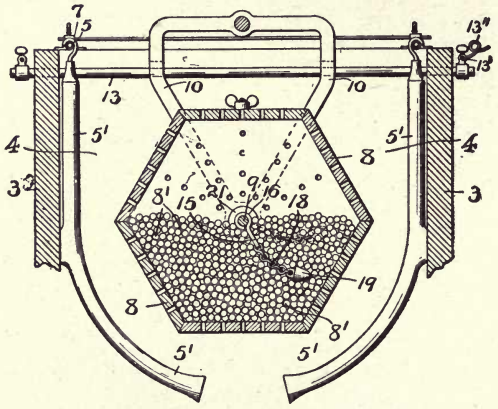

FIG. 69. TRANSVERSE SECTION OF DANIELS PLATING BARREL

The Potthoff Automatic Galvanizing Barrel

Figs. 70 and 71 show an apparatus patented by Louis Potthoff, of the United States Electro Galvanizing Co. of Brooklyn, N. Y. Fig. 70 shows that the plating barrel is resting in bearings and center shaft on top of a plating tank, immersing the plating barrel only about one-third into the solution. It also is provided with inside anodes supported through a center shaft and special anodes supports to prevent the articles from coming in contact with the anodes. After the articles have been plated the spring door is set and the goods will be discharged little by little into the washing drum and carried from here in a screw conveyer into the drying drum and then finally into a tray.

The tumbling barrel 1 is mounted on a shaft supported on the solution tank 2 by bearings 3. Tumbling barrel 1 is rotated by means of sprocket 4 and chain 5. On the opposite side of barrel 1 is a sprocket 6 with driving chain 7, which actuates the sprocket 8 on one end of shaft 9, shaft 9 being journaled in bearing 10, supported on tank 2. Shaft 9 is provided with bevel bear 11, meshing

with gear 12 positioned at one end of shaft 13. Shaft 13 is provided with a bearing 14 in proximity to gear 12. Mounted upon shaft 13 are the washing drum 15, draining drum 16, and drying

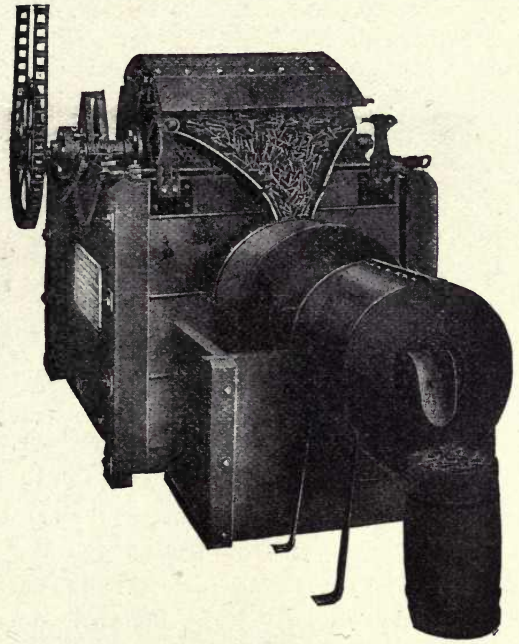

FIG. 70. POTTHOFF AUTOMATIC GALVANIZING BARREL

drum 17. Shaft 13 is preferably slightly inclined to assist the progressive movement of articles treated in washing drum 15, draining drum 16, and drying drum 17.

When the tumbling barrel 1 is rotated in the direction of the arrow 18 the contained material is subjected to the combined tumbling and plating treatment, and at the same time the devices for subsequent mechanical handling of the material are operated to progress the material through the various operations and finally sorted and collected in a suitable receptacle for shipment or storage.

Tumbling barrel 1 comprises a barrel having its inner periphery covered with porous material, preferably cocoa-matting 21, upon which strips 20 are placed, in which strips 20 there are provided holes of such size as to prevent the articles treated in barrel 1 from projecting therethrough. For the cocoa-matting covering are

claimed many advantages over material heretofore employed for this purpose, for by means of cocoa-matting the articles are given a high polish, and no obstruction is offered by the cocoa-matting to the passage of the electric current. Strips 20 may be made of wood or other insulating material. The barrel 1 is supported on tank 2 by means of spiders 22 joined to shafts of sprockets 4 and 6, respectively.

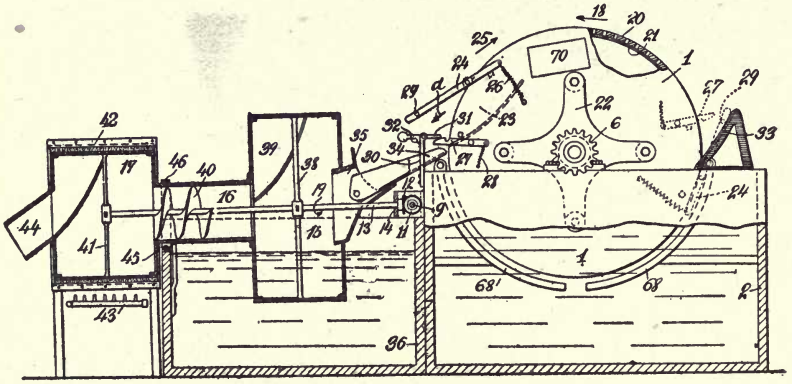

FIG. 71. SECTION OF POTTHOFF AUTOMATIC GALVANIZING BARREL

Within barrel 1 a pocket 23 is formed by extending across the barrel an inclined plate making an angle with the curved side of barrel 1, and a pivoted, automatically actuated door 24 closes the opening at the end of pocket 23. As shown, the pocket 23 extends transversely across barrel 1, opening within said barrel so that when said barrel is rotated in the direction of arrow 25 articles will be caught by pocket 23 and will be in a position to be discharged upon the automatic opening of door 24. Door 24 is provided with springs 26 and latching devices whereby to automatically open the door upward when the latching devices are tripped.

On the ends of barrel 1 are pivoted latches 27 controlled by springs 28. Latches 27 co-operate with pins 29 on the door 24, so that normally latches 27 hold the door 24 in closed position against the tension of springs 26.

Supported by standards 30 on tank 2 are pivoted tripping fingers 31, one end of each finger 31 co-operating with each of the latches 27, the other end of each finger 31 being weighted and further provided with a lug 32 contacting with standard 30 to maintain normally each finger 31 in a horizontal position and preventing

further rotation in the counter-clockwise direction. When barrel 1 is rotated in the direction of arrow 18 the latches 27 will depress the fingers 31 without being tripped, but upon reversal of rotation in the direction of arrow 25 fingers 31 will trip latches 27, allowing the door 24 to open automatically and permit material caught in pockets 23 to be discharged from barrel 1 outside the plating tank.

Mounted on tank 2 on the opposite side are stationary cams 33, which are engaged by pins 29 to close and latch the door 24. This occurs upon continued reverse rotation of the plating barrel, and the door will again automatically open to discharge a further quantity of material caught by pocket 23 when the latch 27 is again tripped.

Chute 34 is pivoted on funnel member 35, which is mounted on washing tank 36 by means of arms 37.

Washing drum 15 is composed of perforated material mounted on shaft 13 by means of a spider 38. At one end there is an opening registering with funnel member 35, and at the opposite end is a pocket 39 positioned so that articles contained in the drum when rotated in the direction of the arrow 19 will be caught in pocket 39 and discharged into the draining drum 16. Draining drum 16 is preferably connected with washing drum 15, and, as shown, may be similarly constructed of perforated material.

Connected with draining drum 16 and having an opening receiving the discharge from pocket 39 is the drying drum 17, which may be supported by a spider 41. The drying drum 17 may be formed of perforated material, and with an outer covering of asbestos or similar material. Drying drum 17 is preferably provided also with a stationary housing 42.

43 is a heater disposed below the drum 17, shown as a plurality of gas jets, but obviously any other type of heating means may be employed. Drying drum 17 is further provided with a combined discharging pocket and chute 44, which pocket 44 is so positioned that articles are caught therein at the bottom, and discharged at the top, when the drum is rotated in the direction of the arrow 19.

The washing drum is of such diameter or so positioned as to be partially immersed in the washing liquid in tank 36, which washing liquid may be continuously replenished by means of suitable supply and discharge pipes. The draining drum 16 is of

smaller diameter than the washing drum 15, and, preferably, one end of draining drum 16 bears upon the upper side of tank 36, the bearing friction being relieved by anti-friction roller devices 45 co-operating with a bearing ring 46 on draining drum 16.

The Schulte Mechanical Galvanizing Barrel

Illustration 72 shows a plating machine resting and traveling on two rings, one acting as a gear and the other as a current connector. It is substantially constructed of 2-in. cypress. The standard size barrel is 36 in. in diameter and 12 in. wide, resting in a tank 53 in. long, 21 in. wide and 33 in. deep (inside measurements).

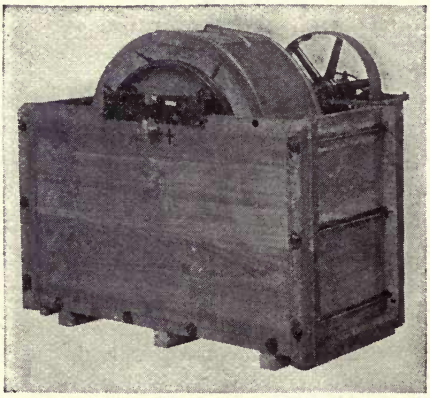

FIG. 72. SCHULTE MECHANICAL GALVANIZING BARREL

The apparatus is also constructed so as to allow a large amount of anode surface within the drum without interfering with the articles to be plated; doing away entirely with the necessity of perforations, making it possible to plate successfully the smallest articles such as needles, pins, rivets, screws, etc. The drum in traveling clockwise subjects the articles thoroughly to the action of the electric current, thus plating evenly.

The most important features of this new apparatus are the methods of loading and unloading of its contents. These are shown in Figs. 73 and 74.

The lid is removed from the drum and the loading of the articles is done as shown in the illustration, without removing the drum from the solution and disconnecting it from the plating current.

The unloading of the articles plated from the drum is done in the simplest manner. The perforated carrier is inserted in the place of the lid and in one revolution of the drum is filled. This opera-

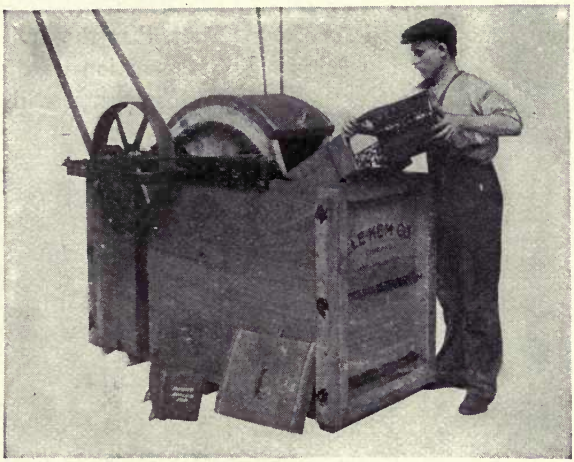

FIG. 73. LOADING SCHULTE BARREL

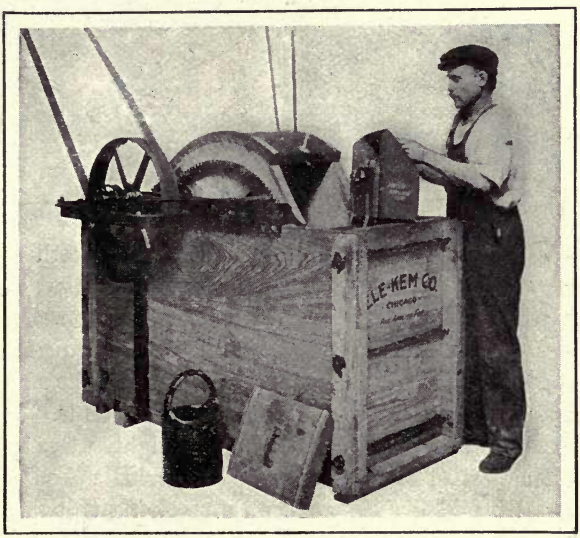

FIG. 74. UNLOADING GALVANIZED ARTICLES FROM SCHULTE BARREL

tion is repeated until the entire finished plated articles are removed leaving the solution intact in the drum and ready for repeated use.

The Ele-Kem Galvanizing Barrel

A saw-toothed barrel lining is the chief feature of this construction. The object of this is twofold. First, that the articles to be plated may be thoroughly subjected to the action of the electric current. As the barrel rotates from left to right, it will be noted

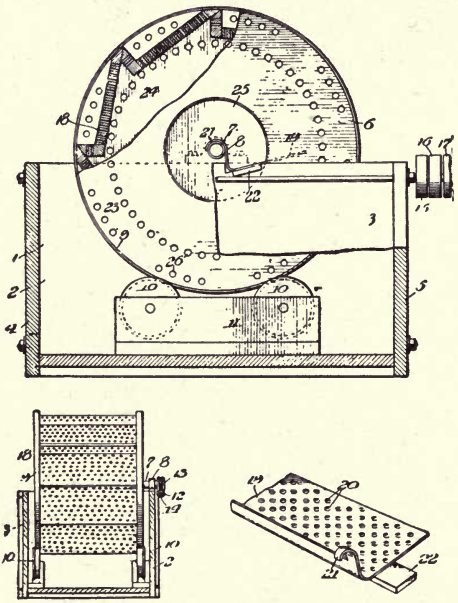

FIG. 75. SIDE VIEW OF ELE-KEM BARREL WHEN USED AS A DRYER

that the load is carried successively on these saw-teeth and when reaching the half turn, the load is shoveled over so that every part of the mass to be plated is presented to anodic action.

The saw-tooth construction has, however, a second mission equally important to the first, in that it does away with the necessity of removing the barrel for the discharge of its contents. It will be seen that as the barrel rotates from left to right, when the action is reversed, a part of the plated mass is carried up on the angle of the saw-teeth and is discharged on a receiving trough or chute. The continuance of the rotation insures the depositing of the entire plated load down to the last rivet, screw or buckle. From

the trough, which receives the articles so deposited, the load is raked by the operator or the slope of the trough can be so adjusted as to carry the load out by gravity.

The barrel construction can be used by modifications of its form for the purposes of plating, burnishing or drying. The barrel is substantially constructed of 2-in. cypress or oak, as desired. The standard plating barrel is 3 ft. in diameter and 3 ft. in length. It has a 14-inch opening in the front through which the goods

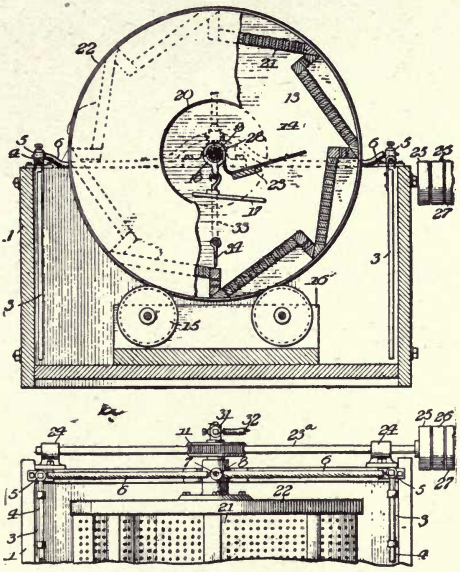

FIG. 76. DETAILS OF ELE-KEM BARREL

are charged and discharged. In the standard barrel there are eight saw-tooth steps. These thoroughly mix the articles by the shoveling process referred to and effectively prevent their sliding en masse.

The barrel rests in a tank 2 ft. deep, 3 ft. 6 in. in length and 3 ft. 6 in. wide and is driven by a worm and gear with a reverse pulley. When the apparatus is running clockwise, the articles are plated and, by reversing the movement by means of the shafting belt, the goods are unloaded, as previously described, on a perforated chute. The goods can be raked or shoveled into a container, pail or tray, from which they can be transferred to the hot water or into a drying machine.

In addition to the outside anodes, there is an inside, adjustable flat anode hooked to the hollow, central shaft, both connected and renewed. The means of connection are novel. The shaft is hollow

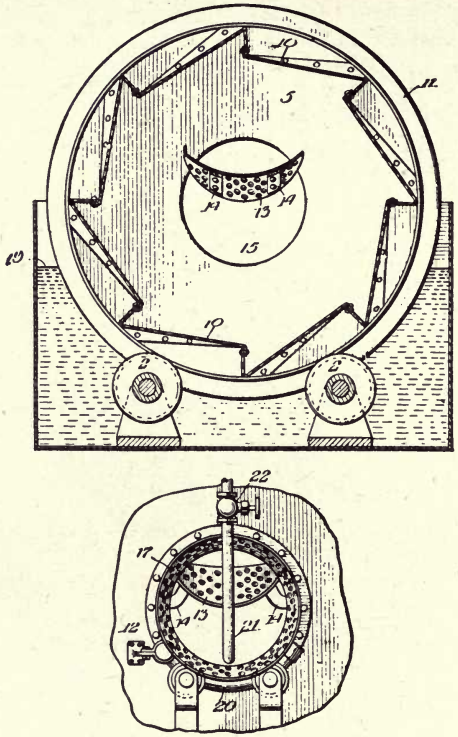

FIG. 77. SECTION SHOWING SAWTOOTHED LINING OF ELE-KEM BARREL

and through it runs a copper rod insulated by a rubber hose and an extension from this rod leads into the solution on the inside of the barrel and makes connection with the goods to be plated.

In Fig. 75 will be noted the barrel adapted for drying purposes. It is made out of perforated galvanized sheet metal and installed in an iron tank holding hot water. The barrel is driven by a sprocket wheel and a belt on a small shaft. The goods to be dried are placed at the rear opening of the drum and are elevated in the course of rotation and discharged through a perforated cylinder extending in front of the drum, and thence into a suitable container. In handling castings or any other material,

the hot water is sufficient to bring about a satisfactory drying. For small, light articles or stampings, a steam coil is placed beneath the extended cylinder. In special cases a compressed air supply is delivered to the inside of the drum and forced through the goods,

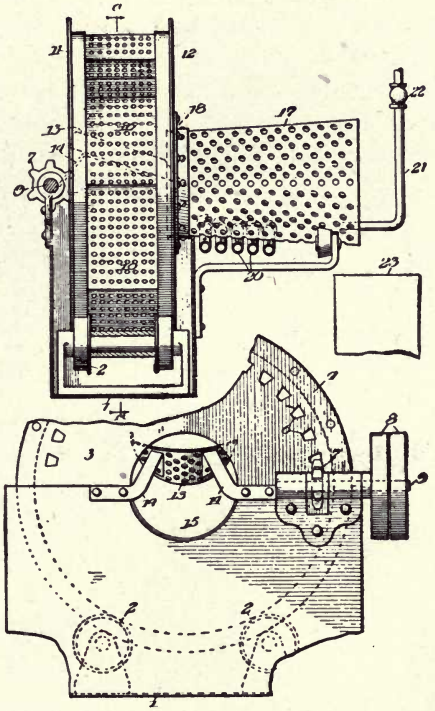

FIG. 78. DETAILS OF LINING AND SHAFT CONNECTIONS

thus insuring absolute drying and doing away with the necessity of using sawdust, etc.

This machine is patented by Louis Schulte and sold by the Ele-Kem Company of Chicago.

A Cleaning, Rinsing and Plating Barrel Unit

Figs. 79 to 84 give a view and details of a plating barrel of a smaller type so constructed that it easily can be removed from one tank into another and thereby allow the cleaning, rinsing and plating to be done without removing the articles from the barrel from the start until the complete process is accomplished. The

plating container or barrel travels on a ring fastened through spokes to the walls of the barrel and the ring travels on a small sprocket wheel, set in motion by a belt or little motor. This machine is patented by Louis Schulte of Chicago.

By the system of cleaning, rinsing and plating without handling the articles, it not only reduces time lost in preparing articles to be plated, but increases the output with less labor.

The mechanical plating barrel, as shown by the accompanying cut, has three wooden tanks with a rotating shaft on each one; on the end of this shaft is mounted a sprocket wheel which engages with the carrier ring supporting the basket or barrel.

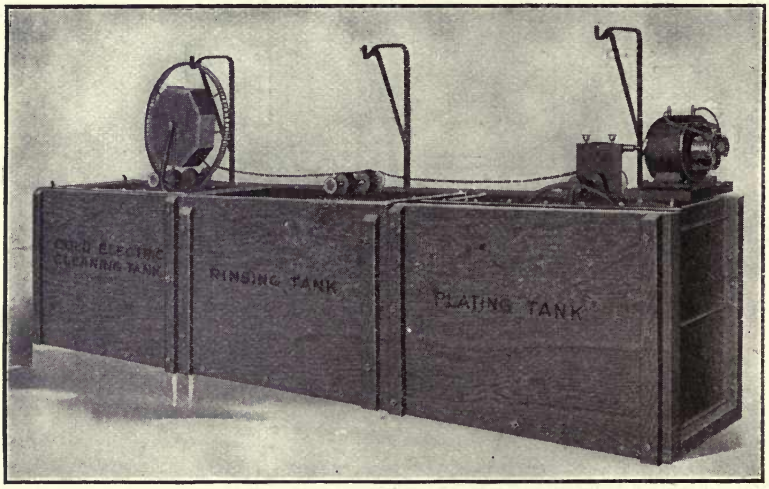

FIG. 79. FRONT VIEW OF COMPLETE PLATING UNIT

The carrier ring, being perforated to engage the teeth on the small driving wheel, insures a positive drive.

The three rotating shafts are connected by means of sprocket wheels and chains, which are driven by motor or belt from first tank.

Fig. 82 is a top plan view of an electroplating device embodying a modified form of the machine. Fig. 83 is a vertical longitudinal section of the device shown in Fig. 82. Fig. 84 is a vertical transverse section taken on line *y*—*y* of Fig. 82.

The preferred form of construction, as illustrated in the drawings, comprises a tank 1 formed of non-conductive material, said

tank being open at its upper side. Arranged at the upper edge of the tank 1 is a shaft 2 which is mounted in suitable bearings 3 and 4. Provided at the outer end of the shaft 2 is a pulley 5 adapted for engagement by a belt in rotating the shaft 2. Provided at the inner end of the shaft 2 is a gear 6. The gear 6 meshes with an annular internal gear 7, which depends therefrom into the tank 1 as clearly shown, the gear 7 resting loosely upon the gear 6, the same being held in mesh with said gear 6 through

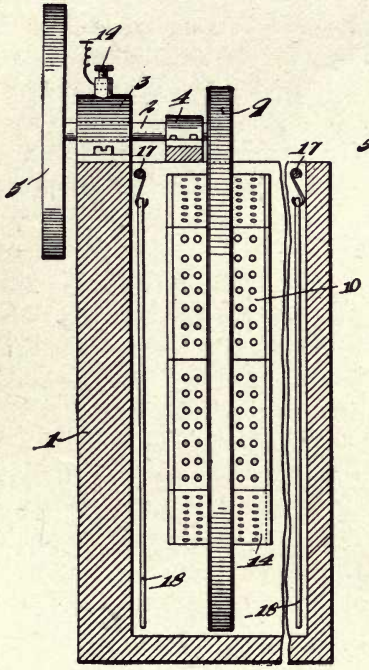

FIG. 80—VERTICAL TRANSVERSE SECTION

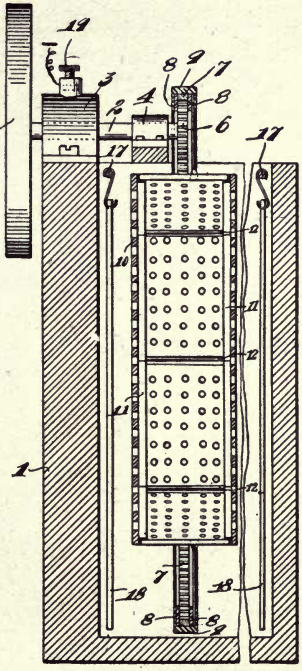

FIG. 81—SECTION SHOWING CONTAINER

gravity. The opposite sides of the gear 7 are provided with inwardly extending flanges 8, which serve to hold said gear in mesh with the gear 7, a channel being thus formed. Surrounding the outer side of gear 7 and the corresponding sides of flanges 8 is a covering 9 of insulating material, preferably rubber. With the arrangement disclosed it will be seen that upon rotation of the shaft 2 gear 7 will be propelled thereby, the latter being caused to rotate in the tank 1, as will be readily understood.

Arranged centrally in the gear 7 is a holder or container for the articles which it is desired to plate. This holder comprises a hollow foraminated body 10 of non-conductive material such as wood, and a conductive frame formed preferably of metal, which consists of the annular angular members 11, which are arranged at the opposite sides of the body 1 and connecting bars 12 which extend between the members 11 at intervals. The members 11 and 12 are so arranged that surfaces thereof will be exposed to the interior of the holder container and so that in use articles arranged in the body 10 will contact with said surfaces and thus establish an electrical connection between said articles and the frame of said body. Said body frame is rigidly secured to the gear 7 through the medium of radiating bars 13 also of conductive material, and so that in use the electrical current passing through the goods contained in the holder will pass through the frame members 11 and 12, through the arms 13 and thence through gear 7 and gear 6 meshing therewith to the shaft 2 to complete the electrical circuit as hereinafter described.

A section 14 of the peripheral wall of the body 10 is slidably mounted in order to constitute a door for gaining access to the interior of said body, the lateral edges of the section 14 being in dovetail connection with the adjacent edges of said body, the frame member 11 at one side being cut away as at 15 in order to afford clearance for said section as will be readily understood. The door section 14 is releasably secured in closed position through the medium of a suitable locking device 16. The inwardly extending flanges of the frame member 11, at the opening which is formed upon removal of the door 14 are cut away.

Arranged in the tank 1 adjacent the upper edge thereof and at either side of the holder or container are bars 17 from which depend anode-forming electrodes 18. Upon bearing 3 and corresponding extremities of the bars 17 are binding posts 19 and 20 respectively for connecting the same with a source of electrical energy. The circuit which is thus formed includes the frame members 11 and 12 of the holder or container which form cathodes and the electrodes 18 which constitute anodes, said electrodes being electrically connected in order to close the circuit by the electrolyte which is introduced into the tank 1 in the electroplating process and the articles arranged in holder for plating.

Operation of the Plating Barrel

First, place the articles to be plated in the rotating basket.

Second, suspend basket on rotating sprocket on cold electric cleaning tank for a sufficient length of time to clean the work. This depends upon the condition of the same and may require from five to fifteen minutes.

Third, transpose the basket from cleaning tank to the rinsing tank, letting the basket rotate in the rinsing tank for a period of two to three minutes.

Fourth, then transpose the basket from the rinsing tank to the plating tank—allowing it to rotate therein long enough to obtain a plate sufficient for the requirements.

A plate may be obtained in fifteen to twenty minutes that will stand buffing without cutting through.

After removing articles, they are dried in the usual way.

In operating the device, the articles which it is desired to plate are first introduced into the holder or container body 10 through the door 14. If it is desired to clean the articles before electroplating, a cleansing liquid is introduced into the tank 1 and the container revolved therein through operation of the shaft 2. After cleansing and rinsing of the articles the container is placed in another tank 1 in which an electrolyte is provided or if desired the same will be permitted to remain in the tank 1 from which the cleansing liquid has been removed and into which the electrolyte has been introduced. The container is then rotated as before in the electrolyte. When this is done it will be seen that the articles resting in contact with the frame members 11 and 12 of the container body will become the cathode in the electrical circuit to which the current will flow through the electrolyte from the anode-forming electrodes 18, thus effecting the plating of said articles as will be readily understood. After the articles have thus been plated the container may be removed from the tank 1 by disengaging the gear 7 from the gear 6, such disengagement being readily effected since the gear 7 simply rests upon the gear 6 as above described. After the coat or plating has dried upon the articles, the container may be rotated as before in the empty tank 1 in order to effect burnishing or polishing thereof, it being clear upon rotation of such container the articles will rub against each other and thereby polish the same as desired.

It is thus seen that with the construction set forth, the entire

electroplating process may be carried on without necessitating the removal of the articles treated from the container in which the same are arranged at the commencement of the treatment, the articles being removed from said container only upon completion of the electroplating. This is rendered possible by reason of the detachable arrangement of the container in the tank, said container, where a plurality of tanks are used in the process, being simply removed from one tank and placed in another as will be readily understood. Further with this construction the loss of electrical energy is obviated, since with this construction the circuit is closed upon the insertion of the container in the tank or when gear 7 contacts with the gear 6 and broken when said container is removed from the tank or when the gear 7 is disengaged from the gear 6, the circuit being thus closed only when the container is in operative position. Also with this construction the necessity of a hand operable switch is dispensed with since the breaking and closing of the circuit is automatically effected upon removal or insertion of the container in the tank.

Numerous other advantages of the construction which it is not necessary here to mention will be apparent to those skilled in the art.

A Modified Form of the Cleaning, Rinsing and Plating Barrel Unit

Figs. 82 to 84 show a construction which is a slight modification of that just described. In this construction the container 10 is longer than that of the preferred form and at each end of said container is provided a gear 7 and the parts which co-operate therewith to which the respective ends of said container are connected in the same manner as the gear 7 is connected with the container body 10 in the preferred form. The gears 7 of the modified form mesh with gears 21 which are provided at the respective ends of a shaft 22 which is mounted in suitable bearings 23 provided upon cross pieces 24 which rest loosely upon the upper edges of opposing walls of the tank. The arrangement is such as will be observed that upon rotation of the shaft 22 the container 10 depending therefrom will be rotated in the same manner as the container 10 of the preferred form. The removal of the container in the modified form, however, is effected by engaging the opposite ends of the cross pieces 24 which are formed into grips or handles as shown for this purpose. Rotation

of the shaft 22 is secured through the medium of a gear 25 which is fixed to said shaft midway the ends thereof. The gear 25 meshes with a gear 26 provided upon a shaft 27 which is mounted at the free end of a rocking bearing arm 28, the opposite end of said arm 28 being fulcrumed to a shaft 29 which is mounted in bearings 29′ provided at the upper edge of the tank 1 as shown in Figs. 82 and 84. The shaft 27 is operatively connected with the shaft 29 through a belt 30 which passes around pulleys 31 provided upon said shafts

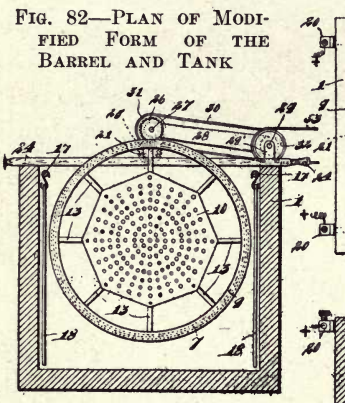

FIG. 82—PLAN OF MODIFIED FORM OF THE BARREL AND TANK

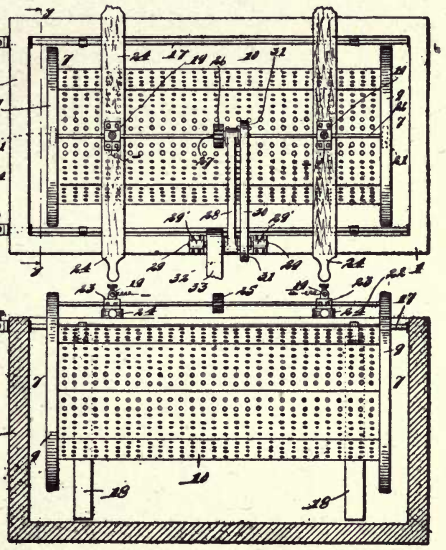

FIG. 84—TRANSVERSE SECTION OF THE BARREL AND TANK

FIG. 83—VERTICAL SECTION OF MODIFIED FORM OF THE BARREL

as shown. The shaft 29 is also provided with a pulley 32 for connection thereof by means of a belt 33 with any suitable source of power supply. With the arrangement disclosed it will be seen that the gear 26 rests loosely in contact with the gear 25, said gears being held in mesh by the weight of the gear 26 and the bearing arm 28, and so that when it is desired to remove the container 10 said arm 28 may be rocked upwardly and outwardly to disengage the gear 26 and permit of lifting of the container out of the tank. The operation of this construction is precisely the same as that above described, anode-forming electrodes 18 being used, which are, however, arranged along the lateral wall or sides of the container 10 instead of at the ends of the container as shown in Figs. 80 and 81.

The Meaker Continuous Type Machine

Figs. 85 and 86 show a machine of the continuous type fixed with horizontal anodes and a rocking device for supplying or loading the machine. From the rocker the goods are conveyed over a perforated tray, connected with the negative current. This tray is continuously rocking or shifting in a downward horizontal position

FIG. 85. TOP PLAN OF MEAKER CONTINUOUS TYPE MACHINE

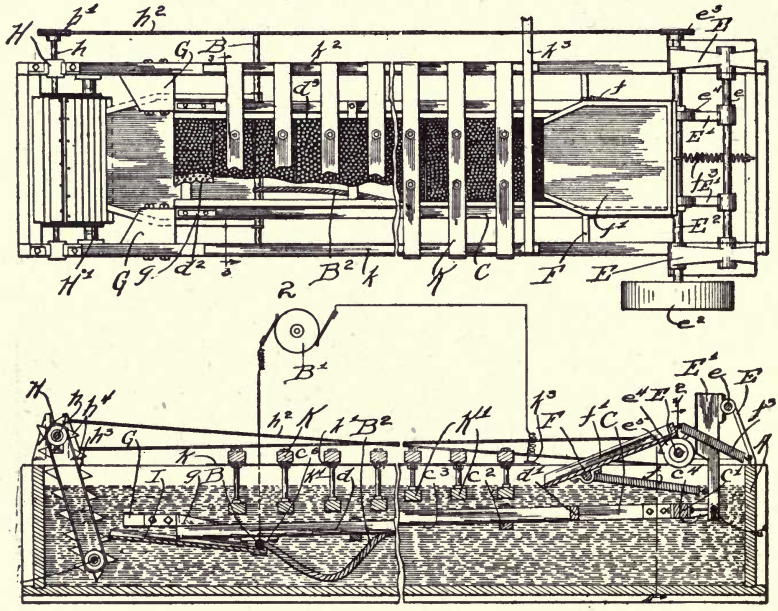

FIG. 86. SIDE ELEVATION OF MEAKER CONTINUOUS TYPE MACHINE

and will finally deliver the plated goods onto an unloading tray into the rinsing tank. This machine is the patent of G. L. Meaker of Chicago.

In said drawings: A indicates a tank for the electrolyte. Said tank may of course be of any suitable size, form or material, but as shown, is an elongated rectangular trough constructed of wood or any material not adapted to injuriously affect or be affected by the electrolyte. B indicates a transverse shaft or rod extending through the sides of said tank somewhat above the bottom and affording connection for one of the conductors from the generator B′ or other source of current. Slidably supported near its lower or discharge

end on said shaft B is a frame C comprising parallel side rails *c* and an upper end rail c^1. Extending transversely beneath and connecting said side rails *c*, are bars c^2, which are rigidly bolted through the side rails *c*, as shown in Figs. 85 and 86, and on which, adjacent each of said side members *c*, and extending longitudinally the frame, is secured a conductor c^3, comprising a sheet or plate of suitable metal. Resting in said frame and upon said conductors c^3, is a tray D, comprising as shown, side rails *d* parallel with the side rails *c*, of the frame, and an end rail d^1. The bottom of said tray comprises a sheet or sheets of metal d^2, conveniently copper, which, to limit the exposed cathode surface, may be lined on the upper side with insulating material d^3, through which project metallic pins d^4. These are shown as rivets, rigidly secured in the sheet metal bottom of the tray and the heads of which protrude above the lining, but of course a non-conducting bottom may be used and straps or bars of metal inserted in its upper surface and connected with the conductors. Said tray is rigidly secured to the side members *c* of the frame by means of plates d^5, which are bolted to the rails *c* and engage over the side members *d* of the tray. The forward or receiving end of said frame and tray are supported at an elevation above the discharge end For this purpose, as shown, a bracket E is rigidly secured upon each of the side walls of the tank at the front end thereof and at its upper part affords bearings for a transverse shaft *e*, on which are journaled jar bars E^1, one for each side of the frame C. Rigidly secured on the forward end of said frame approximately in alinement with the side rails *c*, are forwardly projecting arms or brackets c^4, through the forwardly projecting ends of which extends a shaft e^1 which also extends through the lower ends of the jar bars

Journaled transversely, on the rear sides of the brackets E, at the top of the tank is a driving shaft E^2 which is provided at one end with a driving pulley e^2, adapted for engagement by a suitable driving belt and at its opposite end with a suitable pulley or sprocket wheel (in this instance shown as a grooved pulley), e^3, adapted to drive an elevator to deliver the plated articles from the machine. Rigidly secured on said driving shaft E^2 are cams e^4 one opposite each jar bar as the driving shaft rotates, drawing the frame and tray forwardly, and is shaped to afford a quick release at the forward limit of movement of the jar bar. For this purpose the opposite or release side for said cam projection is abrupt, and to fur-

ther effect quick release, the lower rear side of each jar bar is cut away just below the point of contact with said cam so that when pressed forwardly to its limit of travel, immediate and complete release follows, permitting the jar bars with the attached frame and tray to swing longitudinally the tank. As shown a shaft F, extends transversely through the tank and secured thereon are strong pulling springs *f*, attached at their ends respectively to the jar bars and to said shaft and which act to snap the frame and tray toward the rear after each slow forward movement. Pivotally engaged on said shaft F is the receiving chute f^1, the upper end of which rests on the periphery of said cams and is somewhat wider than the frame and tray. The lower end thereof projects over the tray and tapers to slightly less than the width of the tray to insure the delivery of the articles to be plated across the entire width of the tray. As shown a strong pulling spring f^3 is secured on the end of said chute above the cams and extends obliquely downward and is attached to the end of the tank as shown in Figs. 85 and 86, thus holding the upper end of the chute firmly on the cams. Said cams act to rock said chute on its shaft F, and as the projections e^5, on the cams pass from beneath the chute, the spring f^3 pulls the end thereof down upon the cams constantly, jarring the chute and spilling the contents into the tray.

Rigidly secured on the under side of the frame C are metallic shoes c^6 which bear on the shaft B and are of a length to permit the longitudinal reciprocation of the frame and tray before described and are conveniently provided at their front ends with hooks c^7, which extend beneath the shaft B. Butting blocks G are bolted one on each side of the tank and projecting inwardly into position to afford stops for the frame and tray at the rearward limit of movement. The frame rails *c* are each provided with a stop *g* bolted on its rear end in position to abut the butting block G at the rearward limit of movement to suddenly stop the frame and tray when snapped back by the springs.

Journaled in suitable brackets H on the rear end of the tank is a shaft *h*, having on its outer end a grooved pulley h^1, adapted to receive the driving line or belt h^2, trained around the grooved pulley e^3 on the driving shaft E^2. Journaled transversely in the tank near the bottom thereof and parallel the shafts *h* is a shaft H^1, and trained about said shafts *h* and H^1 is a conveyer belt h^3 having buckets h^4 rigidly secured thereon by riveting or other suitable

means. Each of said buckets is perforated in its bottom to permit the escape of the electrolyte and may be constructed of sheet metal, fiber or any suitable material.

Journaled on the shaft B is a discharge chute I, at the inner or receiving end of which is provided as shown a strap of metal *i*, which extends around the bottom and sides thereof and is apertured to receive and pivotally engage on said shaft B. The discharge end of said chute I extends into position to be successively engaged by the buckets h^4, on the elevator. As the elevator is slowly driven by the belt h^2 the discharge end of said chute is slowly lifted until the chute is about horizontal, at which point it slips off the bucket and falls until engaged to be again lifted by the next succeeding bucket, thereby jarring its contents into the buckets of the elevator from whence they are of course delivered from the tank.

As shown, conducting cables B^2 are secured on said conducting shaft B and are electrically connected with the metallic conductor c^3 in the frame, or if desired may be connected immediately with the metallic bottom of the tray.

Extending longitudinally along the top of the tank on one of the side walls is a conductor *k*, and as shown, consisting of a flat strap or plate of metal, and hinged on one of said side walls are supporting bars K for the anodes. These as shown in Figs. 85 and 86 are bars of wood or any suitable material, each having on the under side thereof a bus bar comprising a strap of suitable conducting material k^1 which rests on the strap *k*, adjacent the hinge, and at the opposite side of the tank rests on a similar conductor k^3. Said conductors k—k^2 are electrically connected by means of a bus bar k^3 which extends across the tank and with which one of the leads from the source of current is connected. Suitable bolts k^4 extend through said bar K and bus bars k^1 and rigidly engaged thereto at the lower ends thereof transversely the cathode tray are the anodes K^1, which may be of any desired number and are conveniently of the metal it is desired to plate upon the articles treated. Said supporting bolts k^4 are progressively longer toward the rear end of the tank so that said anodes are all supported at the same distance above the tray.

From the construction described it is obvious that any of said supporting bars K with its anode K^1 may be swung upwardly out of the electrolyte for adjustment or renewal of the anode or to reduce the plating surface and control the current density. This,

of course, breaks the circuit through such bus bars without disturbing the other anodes or interfering with the operation of the apparatus and affords an important means for regulating the operation. To insure a perfect contact when in operation special forms of construction are frequently used. For this the free end of said bar K is provided with a metallic contact piece k^5 rigidly bolted thereto and flanged under the same to engage the bus bar k^1 and provided with a longitudinally extending vertically set web or knife k^6. This engages wedgingly between contact plates k^7, which are integrally connected with a base member k^8 bolted or otherwise secured to the conductor k^2.

Operation of the Meaker Machine

The operation is as follows: Sufficient of the electrolyte having been placed in the tank A to submerge the tray and the anodes, the articles to be plated are delivered into the tray slowly by means of a chute f^1 and the current is turned on, and the driving shaft actuated from any suitable source of power. The rotation of said shaft with its cams serves successively to elevate and to drop the forward end of the chute f^1 upon the cam, the spring, of course, pulling the end down with considerable force upon the lower portion of the cam and jarring the articles into the tray. The cams also press the jar bars forwardly until the projection e^5 passes the contact points on the jar bars, whereupon the springs f pull the jar bars with the frame and tray supported thereon rearwardly of the tank with some violence until stopped abruptly, thus tending to jar and deliver or roll the articles within said tray toward the lower or discharge end thereof. To facilitate the rolling movement of said articles the bottom of said tray is arranged in successive steps or ledges, and the metallic contacts whether pins or strips are so disposed that the articles being treated are at all times in contact with one or more thereof. The elevator is driven continuously from the driving shaft and as the articles plated successively fall into the chute I, they are moved rearwardly into the buckets by the movement of said chute, the rear end of which is raised slowly on one elevator bucket to approximately horizontal position when the bucket passes from beneath the same permitting the end of the chute to drop upon the next bucket, and below horizontal, thus jarring the articles rearwardly on said chute and into the elevator.

Of course, overlapping metallic plates D^2 of copper or other

suitable metal either with or without its surface covered or partly covered with insulating material, may be employed for the bottom of the tray and in either case after the cathode surface or surfaces have accumulated a considerable coating of the plating metal the cathodes may be removed and fresh plates substituted and the plates so coated or partly coated may be utilized as anodes until the surplus material has plated off. The plates if so used, are of course provided with an aperture at each end which is covered by the side rails *d* of the tray when used as cathodes, but which receive the supporting rods k^4 when used as anodes. In this way all the plating metal is utilized and inconvenience and loss from the accumulation of the plating metal upon the cathodes is avoided.

The anodes in the construction described are capable of being removed independently from the electrolyte and any or all of the same may be swung upwardly, each bus bar breaking the circuit for its anode, when lifted. This enables the plating surface and current density to be at all times perfectly controlled and together with the construction of the cathode elements greatly economizes in current and material.

There are also special devices on the market for special classes of goods, such as tubes, sheets, wire and wire nettings, etc.

Hanson and Van Winkle Pipe and Tube Galvanizing Machine

Considerable ingenuity has been displayed in adapting mechanical means to the handling of large quantities of pipe at an extremely low cost. The plant for work of this kind consists of the dynamo, a series of large circular cypress and iron tanks twelve or more feet in depth, which are arranged in a concrete pit, only a few feet of each tank being above the floor level. The pit is of sufficient size to contain the number of cleaning and depositing tanks necessary and still afford ample room for wiring, connections, repairs, etc.

The work is conveyed on large racks holding from 100 to 150 lengths of conduit. An electric trolley carries the racks and their load from one tank to the next, finally placing the work pickled and cleaned in the galvanizing vat, where electrical connection is made and the necessary amount of zinc deposited. The work never leaves the rack from the time it is first placed in its raw

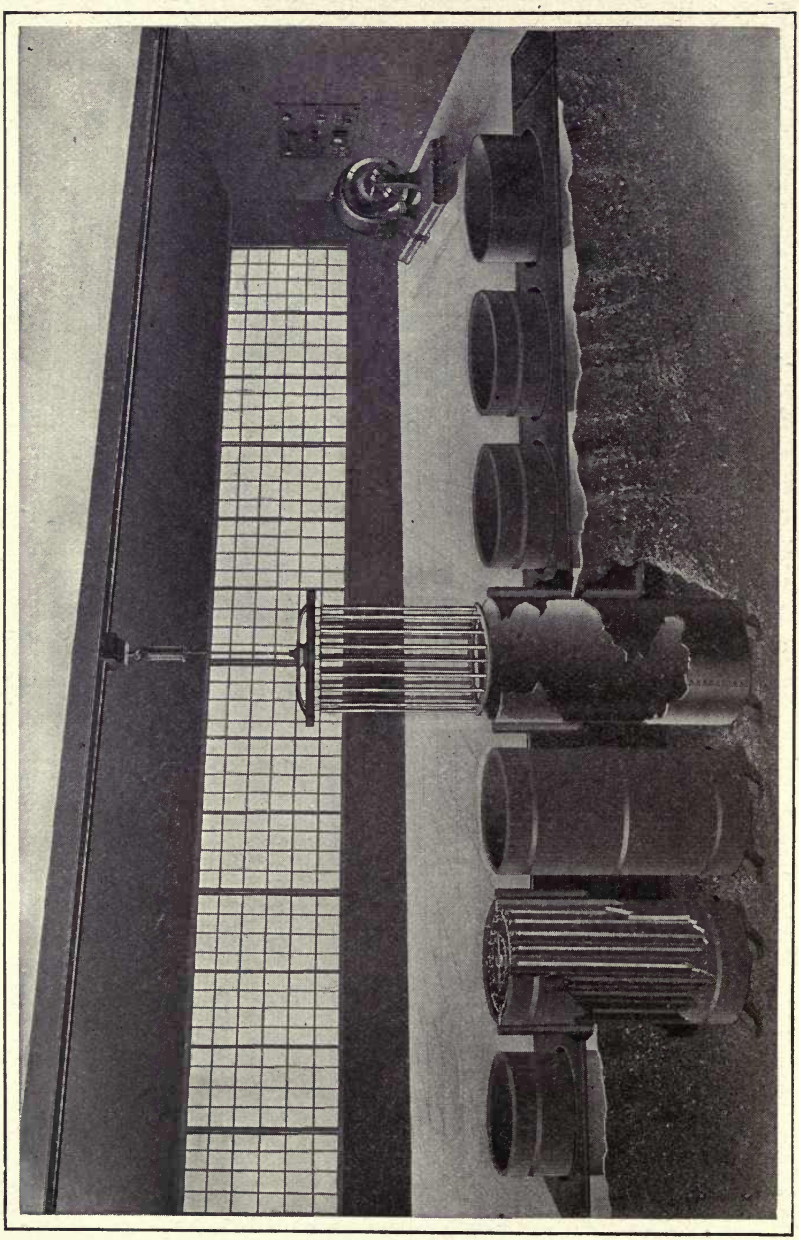

FIG. 87. HANSON AND VAN WINKLE PIPE AND TUBE GALVANIZING MACHINE

state on the carrier until it is delivered to the stock room in a finished condition.

The Potthoff Tube Galvanizing Machine

Figs. 89, 90 and 91 show a plating device particularly adapted for the plating of bars or pipes. The machine is constructed of a large tank of considerable length and the width governed by the length of the goods. The tank is provided with two or more metallic bars carrying the negative current on which the tubes rest and

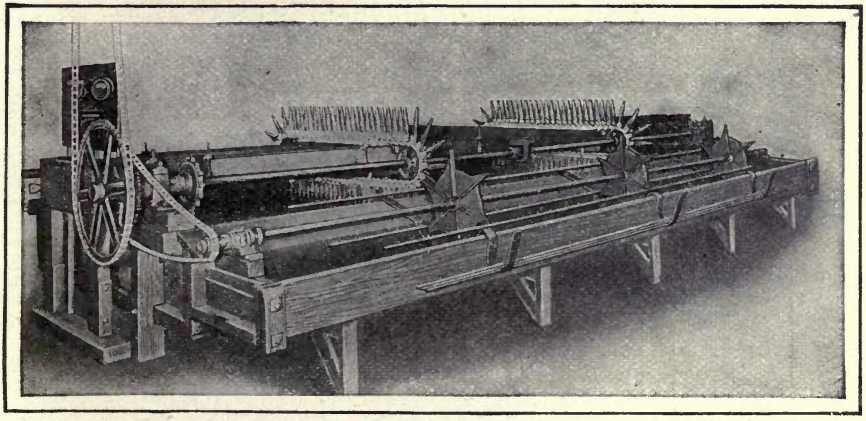

FIG. 89. POTTHOFF TUBE GALVANIZING MACHINE

travel. Above the tank and electrolyte is a special conveyor mounted and so constructed keeping the tubes separate and moving same slowly through the electrolyte. The tubes are automatically discharged from this apparatus into a hot-water tank. This is a patent of Louis Potthoff, of the United States Electro Galvanizing Co. of Brooklyn, N. Y.

1, in Fig. 90, represents a suitable tank or receptacle having mounted thereon the framework 2, carrying hangers 3, in which are shafts 4 4. Mounted on the shafts 4 are sprocket-wheels 5 5, around which run chains or belts 6 6. Mounted at intervals on the chains are pins 7, which engage the work and move it through the solution. The pins 7 may be made of wood or other non-conducting material and so shaped as to cause round work, such as tubes, to roll when engaged by them. It will be obvious that instead of one long chain extending the length of the tank a

plurality of chains may be used to avoid the objection due to sagging of a long chain, this arrangement also serving to change the points of contact between the pins and the work on account of their different alinement. The pin is straight-edged on both sides, instead of straight on one side and curved on the other, and has two separated prongs, so that in cases where the work is short a single chain may be used instead of two chains. The pins are

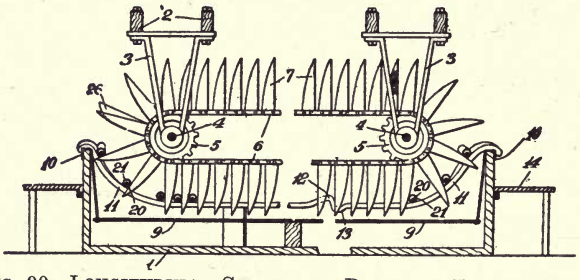

FIG. 90. LONGITUDINAL SECTION OF POTTHOFF TUBE MACHINE

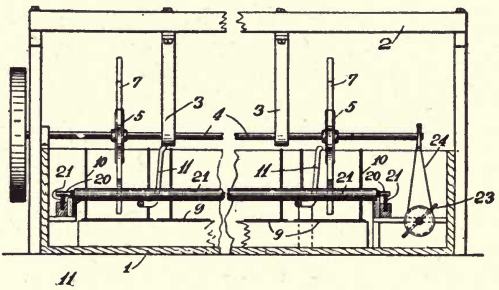

FIG. 91. TRANSVERSE SECTION OF POTTHOFF TUBE MACHINE

made readily detachable, so that one may be substituted for another. In order to change the points of contact between the pins and the work, fixed cams or inclines 8 are provided, against which the work will strike and be moved thereby tranversely, so as to contact with both the pins and the cathode-terminals at different points.

9 9 represent the anodes, which are composed of the metal to be deposited and disposed so that the current may pass from them through the solution to the work and thence out through the conductor-bars 11, which are covered with insulation, except where the work contacts. The anodes may be supported by hooks 10,

which are connected with supply-mains. These cathode-terminals 11 form a track or guide which is inclined to the chains 6, so that as the work is moved along by the pins the points of contact with the cathode-terminal continually change, thus permitting entire covering of the work with deposited metal. The work is fed in at the left and is supported by the pins 7 against the guide-bars 11 until it gets to the horizontal portion and is thereafter merely moved along by the pins, being supported by the bars. Round work is rolled along by the pins as the chain moves; but work of angular shape will slide, and in order to insure that all the contacts with the bars 11 will not be on one side one or more inclines and depressions 12 13 are provided in the cathode, which will cause the work to turn over as it is moved along by the pins. At the opposite end the work is fed out onto a table or other receptacle 14. It will be understood that the bars 11 are to be connected with negative mains. The discharge end of one bar is higher than that of the other, so that the electrolyte will be automatically discharged from the work before it falls on the table.

In order to deposit on the interior of tubes, it is necessary to pass an anode 20 through the tube 27 without having it contact therewith. If an anode be covered with a meshed fabric 29, such as burlap, or cocoa-matting, the passage of metal therethrough is not retarded and burning, due to contact between the anode and the work, prevented. As the inside anode is gradually dissolved, the wrapping becomes more loose, thus permitting free movement of the anode inside of the wrapping as the work moves along.

If desired, the current may be conducted to the inside anode from the outside anode through the solution without using the track 21. As long as the inside anode and the tube are of different polarities no deposit will be made on the inside anode by any positive current which it may receive from any positive conductor, and this condition will be maintained as long as the voltage is not so high as to cause the current to jump across from the inside anode 20 to the tube through the wrapping. The thickness of the wrapping must therefore be proportioned according to the voltage which is to be used. Under some circumstances it will be desirable to use a high voltage and thick wrapping without the track, and in other cases to use a low voltage and thin wrapping in connection with the track 21, connected with the positive mains.

It will be obvious that the use of the inside anode is not re-

stricted to round work, as work of other shapes may be equally well galvanized, and it will also be seen that partial tubes—such as angles, etc.—may be galvanized on both sides by using appropriately shaped anodes.

22 is a stiffening-rod, composed, preferably, of wood, which passes through the inside anode 20 and prevents its breaking when a considerable amount has been dissolved off. For instance, where anodes of zinc are used this stiffening-rod becomes quite essential, because of the brittleness of zinc.

23 represents rotary paddles or propellers which may be driven from the shaft 4 by a belt 24 to force the electrolyte to circulate through tubular work as it is moved along.

In galvanizing small pipes it has been found that air sometimes becomes trapped in the tube and the meshes of the fabric, especially if the tube is carried into the electrolyte horizontally, which permits the electrolyte to rush in at both ends simultaneously. By feeding one end of the tube in before the other the contained air can escape from the end not immersed, and thus prevent the trapping of air within the tube. This can be accomplished by making the straight backs of the pins higher on one chain than on the other, as at 26, so as to incline the tube, and also by setting the pins of one chain slightly in advance of the other, the sprockets being provided with set-screws for the purpose. It will be seen that the tube can be fed in in an inclined position and yet be carried through the tank in a straight line, because the tube comes in on the back edges of the pins and is fed along by the front edges. By setting the pins of one chain in advance of those of the other, the electrolyte will be permitted to run out of the tubes before they are discharged, or, as before stated, one bar can be made higher than the other at each end.

The King Continuous Wire Cloth Machine

Continuous methods for handling hoop iron, corset steel, cartridge steel and wire netting for window screens have been devised which greatly facilitate the turning out of quantities of work daily at a minimum cost. In equipment of this kind the work is placed on large rolls at the beginning end of the process (Fig. 92) and is carried through the various pickling, cleaning and galvanizing operations continuously to another set of rolls at the end of the operation, where the work is reeled up

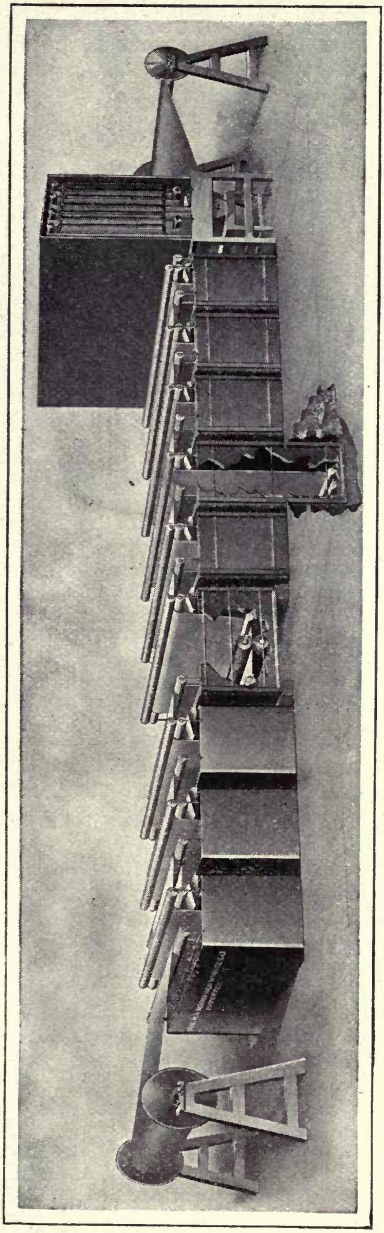

FIG. 92. KING'S CONTINUOUS WIRE CLOTH MACHINE. PATENTED BY HANSON & VAN WINKLE CO. OF NEWARK, N. J.

in a finished condition, impulse being imparted to the various rollers by mechanical means so the work is moved evenly through the various tanks. Plants of this character in the United States are at present turning out over 100,000,000 sq. ft. of galvanized wire cloth each year.

The reference-character 1, in Figs. 93 and 94, indicates any desirable form of supporting frame-work or foundation upon which the various apparatus may be arranged.

FIG. 93. SIDE ELEVATION OF KING'S WIRE CLOTH MACHINE

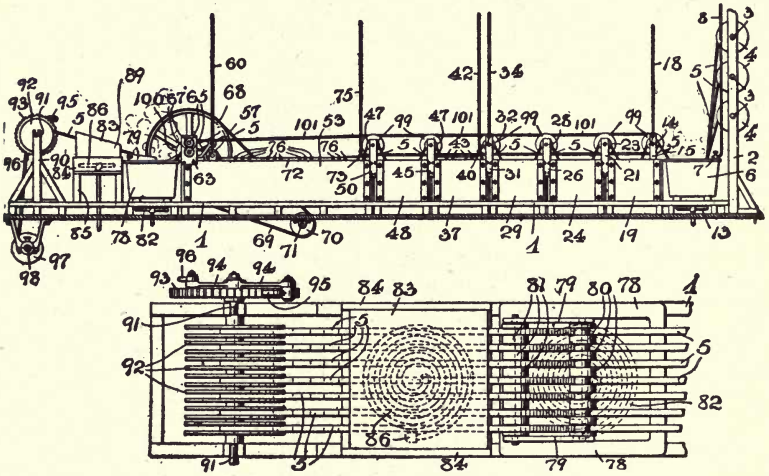

FIG. 94. PLAN OF KING'S WIRE CLOTH MACHINE

The reference-character 2 indicates the standards between which are mounted the shafts 3, bearing the reels or drums 4 upon which the long lengths of metallic material 5 are carried. The said lengths of metallic material 5 are first carried into a cleaning apparatus, which comprises a metallic tank 6 provided with a binding-post 7 to which is attached a wire 8 of an electrical circuit. Arranged within said tank 6 is a frame-work 9 which is provided with bearings 10, in which are suitably mounted rollers 11. The said frame-work is supported upon the bottom of the tank 6 by means of insulating blocks 12. The said tank 6 is filled with a solution of potash which is kept hot by means of a steam-coil 13, or the like, arranged beneath said tank. This potash solution cleanses the metallic material as it is passed therethrough, from

all grease and foreign material which may cling to the surface of the same. The metallic material is drawn from the reels or drums 4 and passed under the rollers 11 so as to submerge the same in the potash solution, and upon emerging from said solution of potash, the strips of metallic material pass over a contact-rod 14 mounted rotatably between standards 15. The said contact-rod 14 is arranged in the electrical circuit, by means of a binding-post 16, one end of which carries a brush 17 which rides in contact with said contact-rod 14, and the said binding-post being connected with an electrical conductor 18, whereby the circuit is established and completed through the tank 6, the potash-solution to the strips 5 in contact with the contact rod 14, and through the brush 17 and binding-post 16 to said conductor 18. Arranged adjacent to said tank 6 is a tank 19 and rotatably arranged in the interior thereof is a guide-roller 20. The tank 19 is filled with cold water and the metallic material is carried from said contact-rod 14, beneath said guide-roller 20, so as to submerge the same in the said water, whereby the potash-solution clinging thereto is rinsed or washed off, as will be clearly evident. Mounted between a pair of standards 21 is a shaft 22 upon which is secured a driving or conveying roller 23, over which the metallic material 5 is carried after emerging from the water in said tank 19. Arranged adjacent to said tank 19 is a tank 24 also provided with an internally arranged guide-roller 25, said tank 24 being filled with a pickling solution for the purpose of removing any scale or the like, which, in cases where the metallic material to be plated has been annealed, may cling to the surface of said metallic material. The metallic material is carried from said driving or conveying roller 23 beneath the said guide-roller 25, so as to submerge the same in the said pickling solution.

Mounted between a pair of standards 26 is a shaft 27 upon which is secured a driving or conveying roller 28, over which the metallic material 5 is carried after emerging from the said pickling solution. Arranged adjacent to said tank 24 is a tank 29 which is provided with an internally arranged guide-roller 30, said tank 29 being filled with cold water, and the metallic material 5 is carried from said driving or conveying roller 28 beneath said guide-roller 30, so as to be submerged in the water, and whereby the pickling solution clinging thereto is rinsed or washed off of the same. Mounted between a pair of standards 31 is a contact-rod

32, and arranged upon one of said standards 31 is a binding-post 33, to which is secured one end of an electrical conductor 34 of an electrical circuit. Connected with said binding-post is a brush-holder 35 in which is arranged a suitable brush 36, the free end of which is adapted to be maintained in electrical contact with said contact-rod 32. The strips of metallic material 5 upon emerging from said cold water tank 29 pass over said contact-rod 32 and are thus brought in electrical contact therewith. Arranged adjacent to said tank 29 is another tank 37 which is provided with an internally arranged guide-roller 38. This tank 37 is filled with a solution of copper or other salts so as to provide a copper or other suitable bath, and the metallic material 5 is carried from said contact-rod 32 beneath said guide-roller 38, so as to submerge the same in the said bath. Secured upon the upper edges of the sides of said tank 37 are contact-rods 39 which are provided with binding-posts 40, a connecting conductor 41 being arranged between said binding-posts 40. One of said conductors is connected with an electrical conductor 42 of an electrical circuit. Suspended from said contact-rods 39, by means of suitable hangers, as 43, are a plurality of anodes 44, so arranged that one group is placed adjacent to the upper surfaces of said strips of metallic-material 5, and the other group is arranged adjacent to the under surfaces of said strips of metallic material 5. Mounted between a pair of standards 45 is a shaft 46 upon which is secured a driving or conveying roller 47, over which the said strips of metallic material 5 are carried after emerging from the said copper-bath; and, adjacent to said tank 37 is another tank 48 which is provided with an internally arranged guide-roller 49. This tank 48 is filled with cold water and the strips of metallic material 5 are carried from said driving or conveying roller 47 beneath said guide-roller 49 so as to be submerged in the said water, whereby any portion of the solution still clinging thereto may be rinsed or washed off. Mounted between a pair of standards 50 is a shaft 51 upon which is secured a driving or conveying roller 52, over which the said strips of metallic material 5 are carried after emerging from the cold water tank 48, and adjacent to said cold water tank 48 is a long trough-like plating-tank 53, adapted to be filled with any desirable electroplating solution. This tank 53 is provided at each end with internally arranged guide-rollers 54, and suitably disposed within said plating-tank 53, between

the said guide-rollers 54 and on a slightly lower plane than said guide-rollers 54, are a plurality of supporting or carrying rollers 55. Mounted between a pair of standards 56 is a contact-rod 57. Secured to the upper edge of one side of said tank 53 is a supporting bracket 58, in the free end of which is arranged a binding-post 59, to which is secured one end of an electrical conductor 60 of an electrical circuit. Connected with said binding-post 59 is a brush-holder 61 in which is arranged a brush 62, the free end of which is adapted to be maintained in electrical contact with said contact-rod 57.

Secured upon one end of said plating-tank 53 are a pair of standards 63 in each of which are arranged a pair of sliding journal-boxes 64. Journaled in said boxes 64 are shafts 67, and suitably mounted or secured upon said shafts are resilient rollers 66. Secured to the outer ends of said shafts 67 are gears 65 which are in mesh with each other and are adapted to drive the said rollers in opposite directions. One of said shafts 67 is provided upon one end with a driving wheel 68 of large diameter, said driving-wheel 68 being connected by means of a belt 69, or the like, with a small pulley 70 on a main power shaft 71. The said strips of metallic material 5 are carried from said driving or conveying roller 52, beneath one of said guide-rollers 54, and then extend longitudinally through said plating-tank 53, being supported by said supporting or carrying rollers 55 and submerged in said electroplating solution, said metallic material then extending beneath the other of said guide-rollers 54, at the opposite end of said tank 53, emerging from the said electroplating fluid or solution and then passing over said contact-rod 57, being in electrical contact therewith, and thence through or between the said resilient rollers 66. Secured upon the upper edge-surfaces of the sides of said plating-tank 53 are contact-rods 72, provided with binding-posts 73, a connecting conductor 74 being secured to and joining in electrical circuit both of said contact-rods 72, one of said binding-posts being connected with an electrical conductor 75 of an electrical circuit. Suspended from said contact-rods 72, by means of hangers 76, are a plurality of anodes 77, which are arranged so as to be grouped between the said guide-rollers 54 and each of the said supporting or carrying rollers 55. The said anodes 77 are further arranged in such a manner so that some of the same extend laterally across said

plating-tank 53, adjacent to the upper surfaces of said strips of metallic material 5, and other anodes extending laterally across said tank, adjacent to the under surfaces of said strips of metallic material 5. Arranged adjacent to said plating-tank 53 is a metallic-tank 78, which is provided with frame-members 79 between which are mounted an internal guide-roller 80 and an outer guide-roller 81. This tank 78 is adapted to be filled with hot water, which is kept hot by means of a steam-coil 82, or any other desirable heating unit, said coil being arranged beneath the bottom of said tank 78. The strips of metallic material pass from said resilient rollers 66, beneath the said internally arranged guide-roller 80, so as to submerge the said strips of metallic material 5 therein, for the purpose of thoroughly cleansing and washing off of the same any of the electroplating solution still clinging thereto, the said strips 5 then being carried over said outer guide-roller 81, and thence through the hood 83 of a drying apparatus, said drying apparatus being arranged adjacent to the end of said metallic tank 78. This drying apparatus comprises a box-like compartment 84, supported upon a frame-work or legs 85, and arranged therein is a steam-coil 86, or any other desirable heating unit. Connected with the compartment 84 and arranged above said steam-coil 86 is a perforated plate 87, over which is arranged the said hood 83, the same being provided with openings 88 at each end for the entrance and exit of said strips 5, the said hood 83 forming a drying chamber 89.

Mounted between a pair of standards 90, which are located adjacent to the drying apparatus, is a shaft 91 upon which are secured suitable receiving reels or drums 92, upon which the said strips of metallic material 5 are rolled or wound after passing through said drying apparatus. Secured upon one end of said shaft is a ratchet-wheel 93, and pivotally arranged upon said shaft, adjacent to said ratchet-wheel 93, is a vibrator-arm or lever 94, the free end of which is provided with a stud to which is pivotally connected a pawl 95 which is adapted to engage with the teeth of said ratchet-wheel 93. The means for operating said vibrator-rod or lever 94 and the pawl 95, to turn or drive the said ratchet-wheel 93, comprises a crank-shaft 96, one end of which is pivotally connected with said vibrator-rod or lever 94, and the other end of which is connected eccentrically with the side or plane-surface of a pulley 97 secured to a main power-

shaft 98. The reciprocating action of said crank-shaft 96, by means of said vibrator-rod or lever 94 and its pawl 95 thus imparts to said ratchet-wheel 93 and the shaft 91 a rotary motion as will be clearly evident. This motion is slow, but very positive, and assures the drawing of the said metallic strips 5 through the various devices of the apparatus hereinabove described, and it is finally reeled or rolled in its finished condition upon said reels or drums 92. To further aid the drawing or passage of said strips of metallic material through the said various devices of the apparatus, the said shafts 22, 27, 46 and 51, upon which are mounted or secured the said driving or conveying rollers 23, 28, 47 and 52, as well as the various revolving contact-rods 14, 32 and 57, are all provided with pulleys 99, and are operatively connected with a pulley 100 secured upon one of said shafts 65, so as to pass the driving power from one to the other of said shafts and contact-rods 57, 51, 46, 32, 27, 22 and 14, by means of belt-connections 101, thereby reducing the friction and aiding materially in passing the said metallic-strips 5 through the various devices of the whole apparatus.

From the foregoing description of the novel plant for electroplating extraordinarily long lengths of metallic material, it will be readily seen that such material is easily manipulated for the purpose of carrying out the various steps of a perfect electroplating process, regardless of the length of the material to be plated. The material is passed through the various devices and tanks of the apparatus, such as the potash-tank, the pickling-tank, the copper-bath tank, and their intermediate cleansing tanks, continuously without the necessity of frequent handling. As one portion of material is treated to one step of the process, it passes on to the next device, there to be further treated, and another portion follows, in sequence, until the plating-tank is reached, where the metal is deposited on said material in carrying out the actual plating step, and then the finished portion is drawn through the resilient rolls 66 which squeeze off the solution from the finished or plated surface. The further cleansing of said finished or plated surface is accomplished in the hot-water tank, and thence the material passes to the drying apparatus and is finally reeled upon the receiving reels or drums in its finished or plated state. The movement of said metallic material through the various apparatus, while it is continuous is nevertheless very slow, so that sufficient

time is allowed to permit of the completion of each preparatory step, as well as of the main plating-step of the electro-plating process, and each portion of said metallic material is evenly and perfectly treated to the final completion of the said process.

The Root Wire Cloth Machine

Illustration 95 shows an apparatus for electro-galvanizing wire cloth. As clearly shown in the illustration, a plating tank is provided with metallic rollers above the electrolyte and with

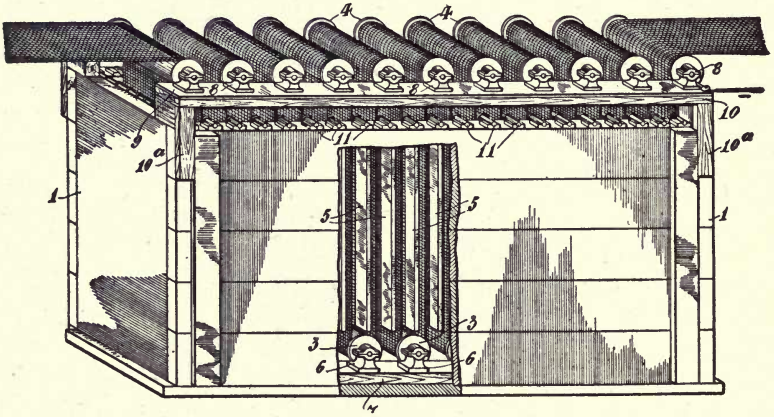

FIG. 95. PERSPECTIVE VIEW OF ROOT WIRE CLOTH MACHINE

wooden rollers below the electrolyte and resting at the bottom of the tank. Between each pair of rollers a set of anodes is adjusted. By this construction a large amount of cathode surface is exposed to the anode surface in a narrow space. This device is a patent of Francis J. Root, of the New York Wire Cloth Company, New York, N. Y. To make the process of electro-galvanizing wire cloth and similar articles, like wire, band iron and sheets a continuous one, similar tanks have to be employed, for pickling, cleaning, hot water, drying and enameling. One row of goods is always connected onto the next one.

The tank 1 is made of wood and is water-tight to hold any suitable bath or solution which may be desired during the plating process. Within the lower portion of the tank and also above the tank are rollers 3 and 4, which extend transversely thereof. The material, moved along by suitable pulling or propelling means,

enters the apparatus, passes over a roller in the upper set, then down into the bath under a roller of the lower set, out of the bath over another roller of the upper set, and so on in vertical folds or loops through the apparatus. It will be observed that the rollers are in staggered arrangement so that those in the lower set are located below the spaces between adjacent rollers of the upper set. Directly below the rollers of the upper set and above the rollers of the lower set are the metal anodes 5 for providing the plating material.

The lower rollers 3 are supported within the tank by means of bearings 6 carried on the longitudinal members 7, and the upper rollers 4 are supported in metal bearings 8 carried on the longitudinally extending members 9 and 10, which are held in place by the uprights 10^a. Either one or both of the members 9 may be made of a metal which will readily conduct electricity and, therefore, can serve as a "bus bar" or common electrical-connecting means for the upper rollers or cathodes, all of which are electrically connected thereto. This "bus bar" or common electrical-connecting means is connected to the negative terminal of an electric circuit, the positive end of which is connected to the anodes.

The anodes 5 are supported in place by and suspended from rods 11 extending transversely across the upper portion of the tank. Each of these rods is provided with a depending member 12 leading to another "bus bar" or common electrical-connecting means 13, to which the positive terminal of the electrical circuit is connected. The anodes are provided with hooks to hold them in place, and it is obvious that one which has been used can readily be replaced by a new one when desired. The anodes are arranged directly over the lower rolls and beneath the upper rolls, and are located within the extremities of the body portion thereof. It is apparent that said anodes are between adjacent vertically extending portions of the folds or layers of the work as it passes through the apparatus, thereby bringing all portions of the two broad surfaces of the work close thereto, thus enabling a uniform deposit of the coating substance upon the work to be obtained.

In coating pieces of work like wire cloth, such as is used for ordinary window screening to keep out insects, this apparatus is particularly useful.

It will be observed that the work passes out of the bath each time it passes over an upper roller and this aids in breaking any

bubbles of gas which may have been formed upon the work and also permits gas accumulation to pass off or dissipate into the atmosphere.

As the rollers in the upper set are all connected to an end of the electric circuit, the work passing thereover will also be recharged prior to being reintroduced into the bath.

With the upper rollers or guiding means located above the bath it will be observed that the work can be readily inspected at all stages in its passage through the apparatus, thereby permitting the apparatus to be operated and the process to be effected in the most advantageous manner.

All of the rollers as shown are provided with flanges to retain the work in place thereupon. The work could, however, be retained in place by other means if desired. The rollers serve for guiding the work through the apparatus and also for providing means to conduct the electricity to the work at several points along its path through the apparatus. When driven they also serve as means for propelling the work.

Schulte Wire Galvanizing Machine

Figs. 96 and 97 show an apparatus for similar purposes, and is so constructed to allow the goods to pass between horizontal anodes on a skeleton framework through the electrolyte. Wires, band iron, etc., are from the start fastened with a long, flat clamp and arranged horizontally, and through the traveling cables or skeleton framework carried through the electrolyte. After this through hot water and finally wound up on spools. This machine can also be used for electro-galvanizing sheets by a continuous method, also small work in bulk quantities when placed in a perforated basket and the basket set on the skeleton framework which travels through the electrolyte. This apparatus is patented by Louis Schulte of Chicago.

In the tank A, filled with the electrolyte B, is arranged an anode formed of the spaced anode-plates C C^1, between which passes the movable cathode-carrier D in electrical contact with contact members D^1, removably secured by screws D^2 to the tank A at or near the ends thereof, as plainly indicated in the drawings. The anode-plates C C^1 are connected with the positive pole of a source of electrical energy—such as a battery, dynamo, or the like—and the contact members D^1 for the cathode-carrier are con-

nected with the negative pole of the said source of electrical energy. The movable cathode-carrier D is in the form of an endless skeleton frame for supporting the articles and for carrying the same through the electrolyte B between the anode-plates C and C^1.

The movable cathode-carrier D, as shown in the drawings, is preferably formed of a number of insulated endless cables D^3, connected with each other by insulated transverse bars or rods D^4,

FIG. 96. SIDE ELEVATION OF SCHULTE WIRE GALVANIZING MACHINE

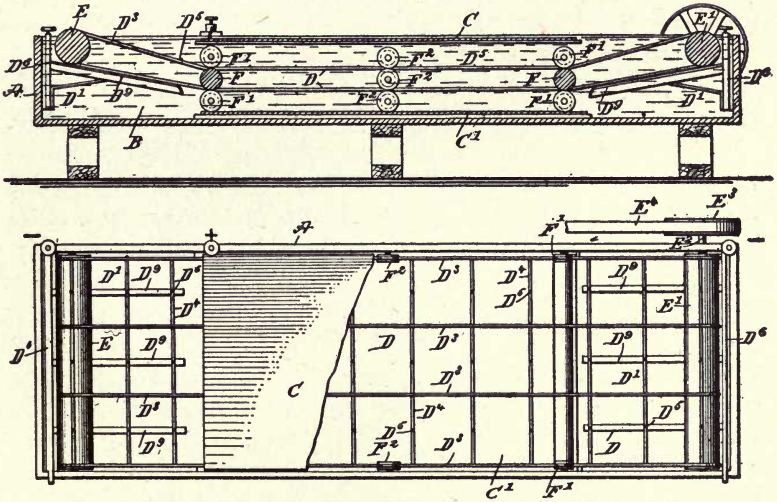

FIG. 97. PLAN OF SCHULTE WIRE GALVANIZING MACHINE

spaced suitable distances apart and each provided with contact-points D^5, having their terminals exposed through the insulating material. Each contact member D^1 for the cathode-carrier D consists of a frame D^6, fastened in position on the sides of the tank by the screws D^2, and the said frame D^6 is provided with an inclined support D^7, carrying springs D^8, pressing the under side of contact-plates D^9, so as to hold the latter in firm contact at their upper faces with the contact-points D^5, previously mentioned, and arranged on the cross-bars D^4 of the skeleton frame.

The insulated cables D^3 pass around rollers E and E^1, journaled in the sides of the tank A at or near the ends thereof, and on the shaft E^2 of the roller E^1 is secured a pulley E^3, connected by a belt E^4 with other machinery for rotating the shaft E^2 and the roller E^1 to cause the skeleton frame forming the movable cathode-

carrier D to travel through the electrolyte and between the anode-plates C and C^1.

The rollers E and E^1 are preferably located near the top of the tank A, and in order to bring the runs of the endless skeleton frame in proper relation to the anode-plates C and C^1 supplementary or auxiliary rollers F F are employed, journaled in the sides of the tank A and over which passes the upper run of the endless skeleton frame and under which passes the lower run of the said frame, the said runs being held in engagement with the rollers F F by grooved idlers or pulleys F^1, journaled in the sides of the tank A. Idlers F^2, similar to the idlers F^1, engage the outermost insulated cables D^3 at a point midway between the rollers F F to properly support the runs between the rollers F F.

The speed of the endless traveling skeleton frame carrying the articles is regulated to cause a complete plating of the articles on the entire outer surface during the passage of the article through the electrolyte in the tank A.

If it is desired to plate small articles, then the same are placed in a metallic perforate tray or basket H, set on the contact-points D^5 of the upper run of the skeleton frame or fastened thereto, so that the articles are passed through the electrolyte B and between the anode-plates C and C^1, the same as the articles above described, and directly fastened to the upper run of the skeleton frame. It is understood that in practice the large articles or the basket containing the small articles are placed in position on the upper run of the skeleton frame at the roller E and taken off the skeleton frame at the roller E^1.

By moving the articles to be plated through the electrolyte the hydrogen is continually removed from the surface of the articles to insure the formation of a bright plating deposit on the articles. It will also be seen that by the arrangement described the electrolyte is kept in motion by the moving cathode to allow of using a very high current, thus finishing the plating in a comparatively short time.

Electrical Equipment

A dynamo driven by a revolving belt or motor, directly connected, will supply the necessary amperes and volts required to deposit the zinc metal from the electrolyte onto the cathode (goods to be plated) and dissolve at the same time an equivalent amount

of zinc from the zinc anodes. A voltmeter and an ammeter, as well as a rheostat, are required to control and regulate the volts and amperes for the different loads and classes of work.

The generator supplying the current is usually placed within 40 or 50 ft. of the galvanizing bath, although this distance may be increased provided the conductors are also increased in size. A safe ruling for every 30 ft. added double the size of the conductor. First, 30 1″; second, 30 2″; third, 30 4″; fourth, 30 8″. Great advance has been made in the United States in the manufacture of dynamos for deposition and it is now possible to procure low-voltage generators up to 10,000 amperes capacity. Such generators can handle 1,000 sq. ft. of work in a galvanizing bath at one time or approximately 16,000 sq. ft. of work in a day of 10 hours. This is based on using a current of 10 amperes per sq. ft. and allowing a 30-minute deposit and the necessary time for filling empty tanks. In no other form of electro-deposition has the demand been greater for generators of low tensions and high ampere capacity than in the electro-galvanizing industry.

Opinions differ as to amount of voltage required. It is agreed that low voltage gives softer and tougher deposit, while when very heavy deposits are required low voltage is absolutely necessary.

Some galvanizers use 2 volts for light work, while others use 6 volts on the same class of work. The latter saves time, but does not give as smooth a coating.

On big work it is necessary to have higher voltage, because of size of tank and distance from anode, which increases resistance.

Copper conductors should be made of solid, flat, round or tubular copper of size sufficient to carry required amperage. 1 sq. in. of copper will carry 1,000 amperes, and 1 sq. ft. of material surface exposed in galvanizing solution will require from 5 to 20 amperes; depending on voltage used and conductivity of solution and anodes.

Anodes

The anode or positive element from which the metal is taken is an important item in the electro-galvanizing process, its purity determining to a great measure the quality of the work and the proper maintenance of the solution. A cast anode is to be preferred, in shape elliptical, round or flat. In a cast anode the structure is more open and crystalline than in the plate form, and

this metal is readily disintegrated under the action of the current. The anode surface exposed should be one-third greater than the cathode surface.

Cost of Installation

The much slower rate at which the zinc is deposited electrically makes the size of the plant larger than for the dipping process, and the first cost is, therefore, greater. It should be noted, however, that the cost of one cubic foot of the electrolyte bath is but a fraction of that of the galvanizing bath.

The solution tanks are usually made of cypress, 3″ or 4″ stock with a lining of a mixture of asphalt and pitch, to which, before it is set, a coating of hot white beach sand is applied, making a hard, serviceable lining. Tanks for pickling are usually made of wood with a lead lining and the tanks for caustics or electro-cleaning are of iron or steel, arranged with steam coils.

CHAPTER XXII

Preparing Work for Electro-Galvanizing

MATERIAL to be electro-galvanized is cleaned, preparatory to immersion in the electrolyte, in much the same manner as it is handled for dipping in the hot process. A comprehensive treatment of these methods is given in Chapters V and VI of this book.

While it has frequently been stated that special attention is required and considerably more caution is necessary in cleaning materials to be cold galvanized, this idea undoubtedly has originated from the fact that material which has not been thoroughly cleaned can be hot galvanized; while the electrolyte process will not act on a surface that has not been entirely freed from foreign matter, such as oil, scale, sand, etc. While it is true that the hot process of galvanizing will largely coat or bridge over such unclean surfaces, material which is treated without being properly cleaned will not resist corrosion so effectively as carefully prepared material, because the impurities set up a corrosive action between the basic metal and the zinc coating. In some cases it has been found that the zinc coating would not adhere to the basic metal and the least shock would loosen it.

Knowledge of the effect of acids and pickles on various forms of iron and steel is necessary in arranging the cleaning and pickling baths. Cold-rolled and malleable iron are readily treated, requiring but mild pickling. Hot-rolled steel is usually covered with a hard scale which must be pickled or otherwise treated. Cast iron is perhaps the most difficult to treat successfully in the electro-galvanizing bath. The foundry turns out so many kinds of castings; the quality depending upon the mixture; the character of the facing used; the temperature at which the metal is poured; the burning of the sand into the casting; the porosity. All of these are factors which make it practically impossible to treat all iron castings similarly. In some instances dry tumblers are used with jacks, the dust exhausted by a blower keeping the castings clean; water tumblers are used with other kinds of work. If the castings have received the proper attention in the foundry,

tumbling will prepare the work so that only a mild pickle need be used.

Removing Sand from Castings

It must be remembered that while hydrofluoric acid will remove sand and scale, great care is required in its use and the strength of the acid should be modified. The solution given below will cause the least danger to the work if not left in the pickle too long.

Hydrofluoric acid, 30 per cent.....2 parts
Sulphuric acid, 66 per cent.....1 part
Water .....8 to 10 parts

A hot pickle of 140 to 160 deg. will work much faster than a cold one. It is always best to use the pickle as weak as will give the desired results in a limited time. A pickle that will not properly treat the castings in two or three hours is a dangerous one to use.

During the process of pickling, quantities of magnetic oxide and scale become detached and, if allowed to remain in the pickle, to be further acted upon by the pickle, will form a serious source of loss. A form of electromagnet has been devised to remove this oxide from the bath.

Removing Oil or Grease

If the material to be electro-galvanized is of an oily nature, that is, if oil or grease has been used in the process of manufacture, the first operation consists in removing this foreign matter by immersion before pickling in a bath, preferably hot, of caustic soda or a like solution that will have for its effect the dissolving of the oil or grease. The strength of the solution and the time required to remove the oil or grease depends somewhat on the condition of the material. If a hot, caustic-soda solution is used, $\frac{1}{8}$ to $\frac{1}{4}$ lb. per gallon will be found to answer general requirements. Material should be allowed to remain in the bath for a period of 5 to 20 minutes. It should then be removed and rinsed in cold water before being placed in the pickling solution, as the caustic soda has a tendency to neutralize the acid.

Removing Mill Scale

The removal of mill scale from iron or steel is generally accomplished by pickling the material in a bath of sulphuric acid, muri-

atic acid (hydrochloric acid) or one of the numerous compositions for the purpose on the market. The strength of the solution used, it will be understood, depends on the thickness of the scale to be removed and the time in which such pickling is to be done. One method recommended is to place the iron in a solution of one part hydrochloric or sulphuric acid to ten parts of water for a period varying from ½ hour to 5 hours, this depending upon the thickness of the scale.

If a sulphuric-acid bath is used, a 4-per-cent.-by-weight solution of commercial acid will be found to answer general requirements. It should be used hot, although a cold solution will answer equally well if the time for pickling is sufficient.

On some classes of work, like chain grips for tires, it is necessary to remove scale, etc., by first hanging in hot caustic soda to remove oil and, after rinsing, to pass quickly through a dip of 40 deg. nitric acid, rinse again and dip work in a 10-per-cent. muriatic-acid solution. After being rinsed again the work is ready for the galvanizing bath and will readily cover in the deepest recesses.

Scratch-Brushing

When a heavy pickle is used, or the work is left too long in the acid, the surface of the work shows a residue which must be removed before the work is placed in the electro-galvanizing bath. This means hand work or scrubbing, which adds largely to the cost of preparing the work.

Heavy pieces of material or of a large surface, such as plates, should also be scratch-brushed after pickling, in order to remove the scum or residue and obtain a thoroughly clean surface. In many instances this can also be accomplished easily and satisfactorily by placing the material in an electro-cleaning solution made up for the purpose in place of scratch-brushing. This solution is usually made from a mild caustic (about 5 per cent. free caustic) solution 6 deg. B.

Copper Flashing

The use of a copper cyanide strike as a preliminary to the deposit of zinc has been largely advocated. Some discussion has arisen as to the value of the copper as a resistant to corrosion. It has been claimed that as zinc is electropositive to both copper and iron, it affords protection to each metal. The oxidizing effect of the

atmosphere will in time affect the zinc coating and change it to a zinc oxide. Whenever galvanic or electrochemical action is set up by the contact of iron and zinc and zinc in the presence of moisture, it is the zinc that is attacked and not the iron. It is claimed by some that there is no galvanic action *per se* in iron coated with zinc and during disintegration the zinc affords protection to the intermediate coating of copper, which, in turn, protects the basic metal. Others claim that the use of a copper flash is bad practice because copper is electro negative to both iron and zinc and will, therefore, lead to more rapid destruction of both these metals when it is brought in contact with them in the presence of the corroding medium. It further adds considerable to the cost.

A dip copper has been used with some success previous to galvanizing and is made as follows:

Water	1 gal.
Sulphuric acid	1 oz.
Sulphate of copper	1 oz.

The work, after being thoroughly cleaned, is immersed for a few seconds in this dip and rinsed quickly.

When the copper cyanide bath is used, the action is similar to that of an electrocleaner. Gas is released from the surface of the work by the action of the current and this has a tendency to throw off the carbon residue which has remained on the work, and in its place on the iron there is deposited a thin film of copper which the zinc readily covers. When the copper begins to show red, then you know the work is clean.

Small material, such as bolts, nuts, washers, rivets, etc., is handled in practically the same manner, except that no scrubbing of the material is required after leaving the pickling bath, the same results being accomplished by tumbling it in revolving barrels.

Castings, according to size, are handled in a like manner, except that cold hydrofluoric acid is used for pickling. In some instances slight heating has been found to be an advantage, and a bath of hydrofluoric acid of 2 per cent. in weight answers general requirements. Sometimes it is scarcely possible to remove the scale from steel without the work remaining so long in the

pickle that the softer or more porous parts of the metal will be over-pickled.

Tumbling and Sand Blasting

The removing of oil, grease, oxide and scale from small articles in quantities is done by the means of tumbling them for several hours in cast-iron or heavy wooden tumbling barrels, running with a speed of approximately twenty to forty revolutions per minute. The articles are charged into the drums and mixed with sawdust. The sawdust will remove and absorb the grease, and the rattling and tumbling of all the articles against each other for a continuous length of time will remove the scale and oxide and produce at the same time a smooth and bright finish to the articles. It is a general practice to fill the drum about one-third with small articles and one-third with sawdust, and this sawdust is discharged at the completion of the process by simply loosening the cover of the drum a little and the sawdust will escape through the opening in the revolution of the drum. After the sawdust is removed entirely, a few shovels of new and clean sawdust are placed into the drum again, and the process repeated to remove the balance of the grease, if any.

Castings are freed from scale and sand preferably by the use of a horizontal sand-blast tumbling barrel. It is considered good practice to wet roll stamped steel with grit or emery until clean. Wire work can usually be cleaned by dry rolling with sawdust to absorb the oil, then rolling with leather chips until bright and clean. The work is then strung on wires or racks and hung in the electro-cleaner for a short time.

The use of sand blast is recommended where the nature of the material and quantity make the operation practicable. Its use eliminates the necessity of the regular pickling process, although sometimes moderate subsequent treatment is necessary before the material is placed in the galvanizing solution. This process is also extensively used for cleaning conduit pipe previous to electro-galvanizing.

Oils and greases should be removed previous to being sand blasted, to permit the sand or crushed steel employed to be used again.

Schulte Grinding and Scouring Machine

The object of the machine illustrated in detail in Fig. 98 is to provide a new and improved machine for grinding,

scouring, scratch-brushing, buffing, and sand-buffing sheet metal, band-iron, wire, and like metal articles and arranged to simultaneously treat both faces of the article in a comparatively short time without requiring skilled labor.

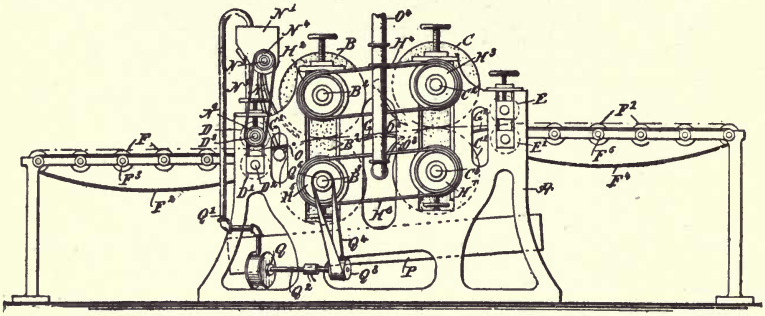

FIG. 98. FRONT SIDE ELEVATION OF SCHULTE GRINDING AND SCOURING MACHINE

Suitable grinding material—such as water, sand, pumice-stone, and the like—is fed onto the top and bottom of the article to be treated immediately previous to the article passing between the rollers B and B^1, and for this purpose a number of nozzles N and O are employed, connected with the lower end of a tank N^1, supported on the top of the frame A and containing the grinding material referred to. Now as the article moves forward between the rollers B and B^1 the grinding material discharged onto both faces of the article is carried along by the latter, and consequently the rotating and transversely shifting rollers B and B^1 grind, rub, and scour both surfaces of the article. In order to keep the material in the tank N^1 properly mixed, a stir-up and transversely extending screw N^2 is arranged in the bottom of the said tank, and on the outer end of the shaft N^3 of the said screw is secured a pulley N^4, connected by a belt N^5 with a pulley N^6, secured to the shaft D^3 for the upper feed roller D, so that when the latter is rotated the screw N^2 in the tank N^1 is rotated to agitate and keep the ingredients of the grinding material properly mixed. It is understood that instead of the screw N^2 other suitable means may be employed.

Water is discharged on the upper and lower faces of the article to be treated previous to the article passing between the second pair of rollers C and C^1, and for this purpose nozzles O^2 and O^3

are provided, connected with a water-supply pipe O^4, leading from a suitable source of water supply. Now by the article passing between the rollers C and C^1 while the latter are rotated and shifted bodily and water is discharged onto the plate at both faces, it is evident that the article receives a final scrubbing, so that the article finally passes in a ground and scoured condition to the delivery-rollers E and E^1 and the transporting-rollers F^1 for carrying the finished article off the machine.

The grinding material used, as well as the water, drips and flows into a trough P, arranged in the lower portion of the main frame A below the rollers B^1 and C^1, and this trough P is connected with the suction end of a pump Q, having its discharge-pipe Q^1 leading into the overhead tank N^1, so that the grinding material and water is returned to the said tank N^1 to be again discharged to the nozzles N onto both faces of the next article to be treated, thus allowing reuse of the grinding material. The shaft Q^2 of the pump Q is provided with a pulley Q^3, connected by a belt Q^4 with a pulley Q^5 on the shaft B^3 of the roller B^1, so that when the latter is rotated the rotary pump Q is set in motion to pump the material from the trough P into the overhead tank N^1.

It is understood that when the machine is in operation both faces of the article are ground and scoured by the use of the grinding material discharged onto both faces of the article previous to its passage between the rollers B and B′.

The pairs of rollers B B′ and C C′ are made of wood or other suitable material or covered with a fabric, according to the nature of the material under treatment and according to the particular finish to be given to the article—that is, whether the same is to receive a scratch-brushing, buffing, sand-buffing, or the like. By passing the article in an inclined position through the pairs of rollers the grinding material and water readily flow back on the article and finally into the trough.

Electro Cleaning

Cleaning work by a low current of electricity is largely practiced in the electro-plating industry. Usually an alkaline solution is used, costing but a few cents per gallon. Steel or iron containers are used for the bath, which is heated to the boiling point by means of steam coils. The tank itself is made the positive by

being connected with the positive pole of the generator; the work in the bath is attached to the negative pole of the dynamo and an e. m. f. of 6-8 volts is used, the work being left under the influence of the current for several minutes. Gas is thrown off freely from the work and the surface is cleaned by the action of this gas, particles of oxide and grease being removed.

CHAPTER XXIII

Electro-Galvanizing Solutions and Their Application

SOME of the earliest experiments in electro galvanizing were made by the French scientists, and present users are indebted to this source, as well as to German and English authorities, for some practical information regarding the action of the various salts of zinc. A number of baths have been patented both in this country and abroad, but the most effective and simplest bath is that made from the sulphate of zinc, in combination with aluminum, zinc chloride or some similar salt, and it has been determined that a bath showing an acid reaction is to be preferred.

It is unnecessary that solutions be used of a composition of poisonous ingredients or those throwing off fumes while in operation, nor is it necessary to operate them at more than the usual room temperature. Their composition should be such as to give the highest electrical conductivity; for the thickness of the zinc deposit and the length of time required for the coating depends on the conductivity to a large extent. Their nature should be such as to decompose and deposit the zinc with a minimum liberation of hydrogen, or the deposit is likely to be found, on examination, to be porous and of a granular and spongy nature. Observance of these conditions will result in deposits uniformly smooth, homogeneous, flexible with perfect adhesion, and in an absolute union between the basic metal and coating.

The upkeep or maintenance of the solution is equally important, and satisfactory results cannot be obtained continuously unless the solutions are at all times working at their highest efficiency.

The cause of unsatisfactory work with the electro-galvanizing process is frequently attributed to improper cleaning of the material, but the fault sometimes lies with the electro-galvanizing solution or electrolyte. While experience in pickling or preparation of surfaces previous to galvanizing affords many little short-cuts which will result in the most satisfactory and quickest results, it does not require the services of an expert or a man of more than average intelligence to master it in a comparatively short time. Attention to details and close observance of results under varying con-

ditions will enable any one to master this part of the electro-galvanizing process.

The electrolyte or zinc solution can be made up from sulphate of zinc (white vitriol) or from chloride of zinc, or from a combination of the two. An addition of conducting salts, such as sulphate of sodium, sulphate of aluminum, chloride of ammonia, etc., can be used to increase the conductivity of zinc solutions. There are also a number of organic and inorganic chemicals recommended and patented for the purpose of producing a more dense and brighter deposit. The majority of these chemicals (of which we will speak more fully later on) act as a colloid through the electric current. The following solution has been worked with success in an open still tank.

Formula 1

Zinc sulphate	200 lbs.
Sulphate of sodium (crystals)	20 lbs.
Sulphate of aluminum	10 lbs.
Boric acid	3 lbs.
Water to make 100 gallons.	

An addition of a few pounds of zinc chloride, or instead a pint of hydrochloric acid, will improve the solution to some extent; also an addition of grape sugar will improve a sulphate of zinc solution and produce a smoother and more uniform finish, at the same time preventing the formation of spongy deposits.

The above solution can be successfully used for all kinds of articles, including wire, band iron, sheets and wire cloth, and will produce by three volts and about twenty amperes per square foot a white, smooth deposit in thirty minutes which will stand three one-minute copper tests, of which we will speak later on.

Chloride of zinc solutions can also be used to better advantage in open tank work, as well as in mechanical plating machines. A good solution is composed of the following:

Formula 2

Zinc chloride	100 to 150 lbs.
Chloride of ammonia	50 to 75 lbs.
Grape sugar	10 lbs.
Water to make 100 gallons.	

In the open bath a low e. m. f. is used, about 3 volts being required with a current of 12 to 15 amperes per square foot of work surface, the density of the solution being about 20 deg. Baume, although a higher voltage can be used if it is desired to shorten the time of deposit. For mechanical apparatus, where the revolving container is used, the solution is brought to a density of 25 to 30 deg. Baume and 8 to 10 volts are used with a corresponding increase in current.

The following zinc solutions have also been used satisfactorily on different classes of work and under varying condition. They are given here so the user of the book may have a basis on which to work in experimenting to find the solutions best suited to his apparatus and work:

Formula 3

Zinc sulphate	44 lbs.
Pure crystallized sodium sulphate	8.8 lbs.
Chemically pure zinc chloride	2.2 lbs.
Crystallized boric acid	1.1 lbs.
Water	25 gals.

Formula 4

Zinc sulphate	50 lbs.
Ammonium chloride	3.1 lbs.
Aluminum sulphate	6.2 lbs.
Water	25 gals.

Formula 5

Cold galvanizing solution for castings:

Zinc sulphate	1½ lbs.
Ammonium chloride	3 oz.
Sulphuric acid	4 oz.
Water	1 gal.

Formula 6

Cold galvanizing solution for barrel plating:

Zinc sulphate	2½ lbs.
Ammonium chloride	6 oz.
Sulphuric acid	4 oz.
Water	1 gal.

Formula 7

Another for regular work:

Zinc sulphate	1½ lbs.
Epsom salts	8 oz.
Boric acid	4 oz.
Ammonium chloride	4 oz.
Water	1 gal.

Formula 8

This solution will give a soft deposit that will stand bending and forming:

Zinc sulphate	2 lbs.
Ammonium chloride	2 oz.
Sulphuric acid	½ oz.
Water	1 gal.

Formula 9

Sulphate of zinc	1½ lbs.
Epsom salts	5 oz.
Sulphuric acid	1/10 oz.
Water	1 gal.

Formula 10

Zinc sulphate	2 lbs.
Sodium sulphate	4 oz.
Zinc chloride	2 oz.
Boric acid	1 oz.
Water	1 gal.
Dextrine	4 oz.

Formula 11

Zinc sulphate	1 lb.
Ammonium chloride	4 oz.
Sodium sulphate	3 oz.
Sulphuric acid	2 oz.
Water	1 gal.

Formula 12

Zinc sulphate	2 lbs.
Aluminum sulphate	2 oz.
Glycerine	½ oz.
Dextrine	2 oz.
Water	1 gal.

Formula 13

Zinc sulphate	2 lbs.
Sulphuric acid	1 oz.
Gum tragacanth	1 oz.
Water	1 gal.

Formula 14

Sodium citrate (crystals)	5.5 lbs.
Zinc chloride	8.8 lbs.
Ammonium chloride	6.6 lbs.
Water	25 gals.

Formula 15

Zinc chloride	2 lbs.
Sal ammoniac	10 oz.
Common salt	3 oz.
Tartaric acid	3 oz.
Water	1 gal.

Formula 16

Zinc chloride	1 lb.
Sodium aluminum chloride	5 oz.
Common salt	4 oz.
Grape sugar	5 oz.

Formula 17

Zinc sulphate	2 lbs.
Iron sulphate	2 oz.
Aluminum sulphate	½ oz.
Sodium acetate	¼ oz.

Formula 18

Zinc sulphate	1½ lbs.
Sal ammoniac	4 oz.
Sulphate of soda	2 oz.
Sulphuric acid	1 oz.
Water	1 gal.

Formula 19

Zinc chloride	2 lbs.
Sal ammoniac	10 oz.
Tartaric acid	3 oz.
Sodium chloride	3 oz.
Water	1 gal.

Formula 20

Sulphate of zinc	2 lbs.
Sulphate of aluminum	4 oz.
Sal ammoniac	2 oz.
Sodium sulphate	3 oz.
Water	1 gal.

Agents for Improving Solutions

The following additional agents are used to improve either the sulphate or chloride solutions, and will cause them to plate brighter and prevent the formation of large crystals. A majority of these additional agents are embodied in numerous patented formulas:

Gelatine, dextrine, glue, alum, powdered licorice, gum tragacanth and tannic acid. These are called "colloids," and when used as additional agents form colloidal solutions or suspensions. They cause the solutions to deposit a smaller crystal, making a close-grained, smooth, bright coating.

Glucose, molasses, benzoic acid, alcohol, sugar and pyrogallol are strong reducing agents, and when used in from three to five per cent. additions produce a smooth deposit with great adherence.

Applying the Coating

After the articles have been freed of all oxides and scales, which means the completion of the pickling process, the goods are then suspended on wires, hooks or racks and thoroughly rinsed in running water and after this operation without any delay are suspended in the zinc electrolyte from a rod between two zinc anodes. The anodes also being suspended on rods opposite to the working rod. The working rod is connected with the negative pole of the dynamo and the two anode rods are connected to the positive pole of the dynamo, marked with "+" sign.

If the tumbling of the smaller goods has been accomplished satisfactorily, there is no further operation necessary and the articles can be transferred from the tumbling machinery directly into the mechanical plating device, in which they remain from thirty minutes to one and one-half hours, according to the quantity of goods to be plated at one time, also according to the different types of machine in use, but chiefly according to thickness of coating required.

There are quite a number of plating machines on the market

to-day particularly adapted for the plating of small articles in large quantities, by the means of revolving barrels, having negative connections; connecting with the goods to be plated and mixing same thoroughly within the barrel, and thus each and every article receives an equal, uniform plating. These mechanical platers differ from each other more or less in their construction, also in the arrangement of their anodes; some are used outside of the barrel and some within the drum only. These have been fully described and their operation explained in Chapter XXI.

Work with deep depressions cannot be coated satisfactorily without using anodes shaped to fit the depressions. Increasing the voltage to make it throw in would not make it cover, but would result in the outer points becoming granular or burnt.

Spongy deposits are caused by a too neutral condition of the bath, and this can be rectified by testing the solution with blue litmus paper. This test should show a deep red at once if the solution is in proper condition, but there should not be enough free acid to blue Congo paper.

If the bath becomes neutral, a ten-per-cent. solution of sulphuric acid and water should be added until blue litmus paper shows a proper reaction.

Such articles as castings, fittings, stampings, etc., that have recesses and depressions, should have some previous treatment.

The method of procedure is that the fixed time of electro-galvanizing be cut in two. A strike or preliminary zinc coating is deposited from a specially prepared zinc solution and is of a dull gray or matt finish. It is advisable then to finish the material in the regular or finish solution, which will then readily coat over the entire surface and leave the treated material of a bright silvery appearance. Its value can be appreciated from the fact that it is productive of a quality of work not possible by any other means, reduces the time of coating and results in an output of more than double that possible with the same size equipment containing only the ordinary electro-galvanizing solution or electrolyte. A zinc coating of 25 to 35 minutes, depending on the nature of the material, deposited in this manner is ample and will be found to answer all requirements.

It is possible to make a heavier deposit by electro-galvanizing processes by leaving in the solution for a long period. Cast-iron rolls have been electro galvanized with coating heavy enough to

stand turning in lathe. This required about ten hours in the regular solutions.

Cost of Operation

The cost of labor and power are the main items of expense in electro galvanizing. Exact figures as to the cost of power cannot be given. A larger firm producing their own steam and electric power as a by-product, figure the cost per kilowatt hour as less than one cent; while a small consumer supplied with electricity by a local power and light company has to pay from four to eleven cents per kilowatt hour, while in comparison the cost of fuel for a hot galvanizing process does not differ to such an extent. The labor cost in electro galvanizing and in hot galvanizing is about the same, while the zinc wasted in the hot process in the form of dross seems to be greater than the zinc wasted by the cold process in rinsing the work from the solution. After a length of time, however, if the possible leakage of tanks and the renewing of the solution is taken into consideration, the cost of waste in comparing the two processes will average about the same.

While more time and chemicals have to be applied for the electric process than for a hot process, the hot process will use a larger amount of zinc metal by one dip, and this leads to the main argument as to whether cold galvanizing is cheaper and better or whether the hot galvanized articles are superior and cheaper than the others.

While the unskilled workman in a hot galvanizing plant cannot prevent the giving of the iron articles to be coated a sufficiently heavy zinc coating, the skilled workman in an electro-galvanizing plant is sometimes forced, through local conditions, to give the customer an inferior galvanized article. Therefore, aside from the above facts, it can be easily determined in any galvanizing plant using the two processes that, if an equal amount of metal is required on sheets, for example, by the hot process, as well as by the cold process, the cost of operating and materials for the cold process will exceed that of the hot process. However, small work in bulk quantities plated in up-to-date mechanical plating machines is less expensive than the hot process.

Numerous arguments have arisen to set forth that a dense and bright coherent electro-galvanized deposit does not require so much zinc deposit as a zinc coating produced by the hot process. This problem is still open for discussion, but practical natural tests

for a number of years, under the same conditions, have proved that the amount of zinc applied to iron will guarantee the length of time the iron is protected from corrosion.

For example, large pieces of iron sheets galvanized by the hot process and large pieces of iron sheets galvanized by the cold process were nailed on top of a roof and additional pieces nailed against the chimney of a factory, and in each instance, where there was less zinc on the cold galvanized sheets, the galvanizing broke down before the hot galvanized sheets. This refers especially to such articles where the electro galvanizing does not enter so easily into the deeper parts of profiled articles, and consequently the difference between hot and cold galvanizing will be much earlier shown.

That this point has been thoroughly recognized and practiced is evidenced by the process of plating employed at the electro-galvanizing plant of the Spirella Company, Niagara Falls, N. Y., illustrations of which are given in Figs. 56 and 57. The problem of supplying corset wires which would effectively resist corrosive attack, due to atmospheric moisture and perspiration, was a serious one. Numerous experiments for several years resulted in the following coatings being applied. The wires are placed for 45 minutes in a copper cyanide bath, 45 minutes in an acid copper solution, 20 minutes in a nickel solution and 90 minutes in a galvanizing solution. This is an exceptional case and is interesting as probably representing the limit of practice in plating for protection, about five pounds of metal being deposited for every one hundred pounds of corset wire.

The argument about the special test is also a delicate one. The Preece test adopted by the United States Government is the most reliable and quickest of all tests, and every electro-galvanizing plant should use it, if only for the purpose of determining or controling the deposition of zinc from the different solutions every day.

The saline or salt-water test, by the means of spraying continuously a 10-per-cent. salt solution for a period of from 14 to 20 days all over the galvanized articles, is also adopted by some concerns. Galvanizing which breaks down before 14 days have elapsed is rejected as inferior.

Another test is to hang the galvanized articles in a pure-water bath in which a continuous stream of air is flowing.

There is also the cinder test and sometimes diluted sulphuric acid is used to test galvanized articles against quick corrosion.

Test for Thickness of Zinc Coating on Armored Cable Strip as Provided by Underwriters' Laboratories, in Effect September 1, 1913

The following test is, in some degree, a measure of the thickness of the zinc coating and should be made on at least two samples (about 4 in. long) of the finished product going through at the time of each visit. Each sample shall be washed in running water and then dipped up and down in a vessel containing either carbon tetrachloride or ether and allowed to dry before being put into the copper sulphate solution. This solution is a saturated solution of C. P. sulphate of copper, using distilled water.

About 100 cubic centimeters of the solution shall be poured into a glass vessel about two inches in diameter. The same sample of solution shall be used for all dips of any one sample, but a new supply of solution shall be used for each new sample. Solution, after use, shall be thrown away and in no case put back into the supply bottle. The portion of solution used for each test shall be brought to a temperature of approximately 65 deg. Fahrenheit before the test is made. This shall be accomplished by setting the beaker containing the solution in a larger vessel containing the warmer or colder water and stirring the solution with a glass thermometer until the proper temperature is obtained.

The sample prepared, as above, shall be stood on end in the solution for one minute. The solution shall not be stirred or the sample moved during the immersion. At the end of one minute the sample is to be removed from the solution and rinsed in running water and then wiped lightly, both inside and out, with cheesecloth until dry. Care should be taken to avoid violent rubbing of the sample and the contact of the surface with the hand or anything else than the white cloth used for drying. The sample must be thoroughly dried before each dip.

Each sample shall be subjected to at least three dips and the dips should generally be continued until the entire immersed surface of the sample is coated with a fixed copper deposit.

The coating will be considered satisfactory, so far as this test is concerned, if the fixed copper deposit (i.e., that which cannot be wiped off) does not show before the second dip and also does not appear on more than 25 per cent. of the surface tested before the third dip and wiping process.

CHAPTER XXIV

The Art of Sherardizing

SHERARDIZING, or dry galvanizing, is a process whereby articles of iron and steel are rendered rust proof by applying a coating of zinc dust. The coating produced by this process is first an alloy with the underlying metal. After this alloying action is completed the outer layer of zinc is deposited, the zinc penetrating into every crevice and cavity radically different from any other method of zinc coating. Briefly stated, this coating is not a pure layer of zinc, but a zinc-iron alloy.

Dry Galvanizing in Prehistoric Times

A process practically identical to this was known in prehistoric times, although used for another purpose. At that time it was known that if certain copper tools and vessels were placed in the ground in certain localities and kept hot for a time by building fires over the place, then, on removal, it was seen that the copper had assumed a light yellow color and had become harder and more durable. They practically secured dry galvanizing, although it was not known that another metal was being alloyed with the copper. Also, in Greek History, according to Aristotle, the "bleaching of copper" was done by the same method.

The Sherardizing process was discovered by accident. Commander H. V. Simpson, of the English navy, was detailed to work out a method of case hardening armor plate for battleships that would not infringe on the Harvey patents which were being used by nearly all governments for rendering armor plate shell proof. These experiments were being tried out in the laboratory of Sherard Cowper-Cowles, of London, a noted English metallurgist. A package of zinc dust had been forwarded Mr. Cowper-Cowles to determine whether it could be used in making an electrolyte for zinc plating. In the course of their experiments they placed a piece of steel in this zinc dust in a case hardening oven and heated it up to see if it would have any hardening effect on metal. When taken out it was covered with a silvery coating of zinc and on examining

under the microscope they found it had penetrated and alloyed the zinc with the body of the metal.

Theory of Sherardizing

Sherardizing may be defined as a process of sublimation, occlusion and adhesion, when considered in connection with the theory

FIG. 99. SECTION OF SHERARDIZED STEEL MAGNIFIED 100 TIMES

of ions. The process of passing directly from the solid to the gaseous state and from the gaseous direct to the solid state, in both cases stepping over the liquid state, is called sublimation.

The theory of sublimation and the "triple point" in connection with sublimation is fully defined and described in many elements of physics. It is a very well known fact that solids sublime. This is easily shown, for example, in the evaporation of ice when it is kept below its melting point. In the case of most solid substances this process is so slow at ordinary temperature that it cannot be detected. At ordinary temperature and pressure camphor, arsenic and many less familiar substances sublime. Solid carbon dioxide will volatilize at—79 deg. C. at atmospheric pressure without passing through the liquid state. Zinc as a solid may change into vapor without passing into the liquid state. For an exact definition of the physical condition of a body a knowledge of the values of all its variable properties is required. The three most important of these are temperature, pressure and volume occupied by unit mass of the substance. These are not independent of each other but are connected by a definite relation called the equation of state, which,

in the simple state of perfect gases, takes the form of the gas law, which is the law of Boyle and Charles.

It is a well known fact that common metals are extremely porous. This is visible under a high power magnifying glass, as well as readily demonstrated by certain physical experiments. Thus, if an iron wire be placed in a vacuum tube and then heated to incan-

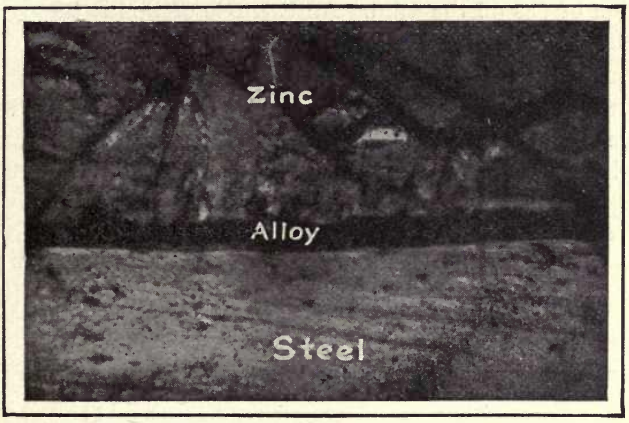

FIG. 100. SECTION OF COLD ROLLED SHERARDIZED STEEL MAGNIFIED 1300 TIMES. NOTE ZINC-IRON ALLOY

descence, as, for instance, by passing a current through the wire, the pressure within the tube rises materially and gas is evolved for a very considerable time, indicating that iron (and practically all other metals) contain large volumes of gases. The condition of the metal may be graphically described as resembling a sponge soaked with water.

The two photomicrographs reproduced in Figs. 99 and 100 show pieces of Sherardized steel magnified so as to show the zinc and iron alloy after Sherardizing.

How Precipitation of a Vapor on Metal Occurs

When a porous solid is easily permeated by a gas and condensation on the surface of the pores of the solid takes place, it is called occlusion. An example of this can be seen in the absorption of 90 volumes of ammonia in one volume of charcoal. Spongy platinum will absorb about 250 times its own volume of oxygen. Paladium will absorb about 1000 times its own volume of hydrogen

and will increase one-tenth of its volume. To produce such a condensation alone would require a pressure of many thousand pounds per square inch. Nearly all metals absorb gases and, being heated, will allow them to pass through readily. An example of this is the fact that hydrogen will readily pass through heated iron.

When a gas is in contact with a solid, there are molecular forces drawing the particles together, and this produces a surface condensation of gas on the solid. An example of this is the difficulty in removing the last traces of air from a vacuum bulb due to the adhesion of the air on the surface. Another example is the frosting of window panes in irregular figures.

There also appears to be an electrical condition accompanying the evolution of gases from a metal inasmuch as the evolved gases usually contain a number of free ions. This is particularly the case if the temperature of the metal is high at the time the gases are given off. Naturally the exposed surface of the metal is the only portion which actively takes part in evolving gases, so that the larger the area of surface exposed the greater the evolution of gas, other conditions being equal.

A further fact, which is well established, is that the presence of free ions has a marked effect in producing a precipitation of a vapor or suspended matter in a gas. It follows, therefore, that if a metal be heated in the presence of a vapor under such conditions that the gases or vapors contained within the metal are in part liberated; then, as the liberated gases or vapors contain some free ions, they will cause the precipitation within the pores of the metal and on the surface layer of a portion of the external vapor in which the metal is heated.

Now it is a well known fact that all materials have a definite vapor tension, depending mainly on the nature of the material, the nature of the surrounding materials, the temperature and the pressure. It therefore follows that under all conditions all substances are surrounded by a certain amount of their own vapor. The vapor can be increased in amount by increasing the temperature and decreasing the pressure.

Methods of Producing Zinc Vapor

Zinc vapor can be produced in several ways from zinc. If molten zinc is boiled in a reducing atmosphere, vapor is given off rapidly and if heated iron is brought in contact with this vapor Sherardiz-

ing would take place. This method, however, is neither convenient nor economical because of the waste of zinc. The most practical and economical method is to use zinc dust, which is obtained as a by-product of a zinc smelter. This dust is practically amorphous and each particle consists of a small inner particle of more or less pure zinc surrounded by a thin coating of zinc oxide.

According to a well known fact, the vapor tension is higher for small particles than for large. It is thus desirable that the zinc be in a very finely divided condition, for the extent or degree of penetration of the zinc vapor in the iron depends upon its vapor tension. It is also desirable that there be as little impurity in the zinc as possible, for not only the zinc, but also the impurities, such as lead, cadmium, etc., will give off vapors, and the combined vapor tension of the mixture would generally be less than that for pure zinc.

As said before, the zinc particles are surrounded by a coating of zinc oxide. This oxide is very inert compared to metallic zinc and has a high melting point. It therefore is very advantageous in the process because it not only keeps the particles of zinc separated, but allows the spheres of vapor surrounding them to act independently with a high vapor tension and permits the temperature to be raised beyond the melting point of zinc without its becoming molten. Therefore, the percentage of inert material in the zinc dust plays an important part in the process.

Since the process of Sherardizing is being carried on all over the country under different conditions and for different purposes, it is impossible to give any specific rules for Sherardizing. The following suggestions, however, can be applied in general to all plants using this process.

The process of Sherardizing can be divided into the following steps or stages, each of which has a definite relation to the whole:

1. Inspection.
2. Equipment.
3. Zinc dust.
4. Cleaning or preparing of surface.
5. Temperature and Time.

As said before, the articles to be Sherardized cannot be selected without increasing their cost, but this does not mean that everything can be Sherardized. If the article is excessively corroded or covered by inburned slag (sometimes found with malleable iron)

to such an extent that ordinary methods of cleaning will not remove it, it will not be advisable to attempt Sherardizing. In this case such articles should be removed on inspection. Many people were of the opinion when taking up this process that anything would Sherardize regardless of the condition of the surface, and this is the prime cause of the dissatisfaction at the introduction of the process.

Just as in the electro galvanizing and the hot galvanizing processes, so in Sherardizing, the surfaces must be thoroughly cleaned. A hot galvanizer or an electroplater would not think of galvanizing an article that was not free from scale, rust, grease, dirt or other impurities, and it is also important that this is done in Sherardizing, if satisfactory results are desired.

CHAPTER XXV

Location and Equipment of the Sherardizing Plant

WHILE the Sherardizing business can be carried on in almost any kind of a building, the floors should be of cement or brick as a safeguard against the excessive heat of the Sherardizing cylinders or drums. Outbuildings of one story are preferable, as it is entirely practicable to combine the pickling and cleaning with the Sherardizing. While the space required for a complete Sherardizing plant varies according to the demands and volume of work to be handled, a plant of a daily capacity of one ton for treating miscellaneous articles, such as bolts, screws, nails, chain, stampings, etc., can be carried on very comfortably in a floor space of 600 square feet.

Little can be said in regard to equipment unless the articles to be Sherardized are determined. If there are bolts, nuts, washers, stampings, forgings or articles of malleable cast iron, the equipment would be very different than in the case where large railroad material, structural iron, etc., are treated, or where continuous Sherardizing is applicable, as with wire, woven wire cloth, nails, sheet metal, chains, etc.

Fig. 101 is a typical layout of a floor plan showing positions of an actual Sherardizing plant. The general equipment of an ordinary Sherardizing plant consists of a furnace, drums, transfer trucks, R. R. track, cooling frame, pyrometer, dust screening machine, ash cans for holding zinc, loading frame, "I" beam, carriage and hoist, drum pulling machine, pickling tubs, tumbling barrels and sand blasting outfit.

The old pickling tanks which are now used almost exclusively for galvanizing work consist of four large wooden tanks set end to end and one iron tank. Each tank has a water and steam inlet and a drain pipe. The new pickling tanks are used for Sherardizing work and consist of eight small tanks set in a row in groups of two. The first tank contains potash, the second hot water, the third hydrofluoric acid, the fourth hot water, the fifth sulphuric acid, the sixth hot water, the seventh lime water and the eighth hot water. Each tank is equipped with a steam and water inlet

and a drain while the hot water tanks also have overflow pipes. An electric hoist running on a Coburn track runs over the pickling tanks and is used to lift the baskets of material from one tank to another. A sand tumbler is also used to clean the material to be Sherardized.

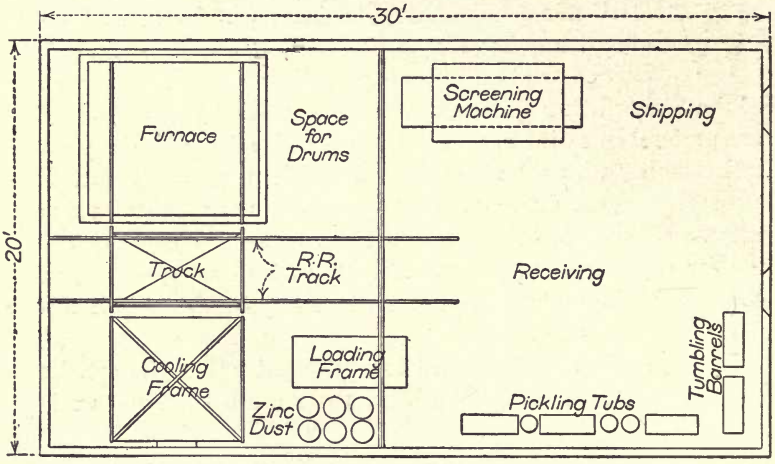

FIG. 101. FLOOR PLAN OF SHERARDIZING PLANT

The Sherardizing Furnace or Oven

There are several different styles of Sherardizing ovens or furnaces in use,which will hold one or more drums, according to the capacity required.

Coke Burning Furnace

Figs. 102 to 106 show the type of a coke burning furnace designed by A. F. Schoen of the New Haven Sherardizing Co. This furnace is especially valuable in suburban districts where no other fuel is available. The furnace is built of 9" fire brick walls reinforced with steel plates; has individual damper controls so that the heat, which passes between two arching bridges, can be directed to either the front or the rear of the furnace. It is built on the down draft principle, the heat passing directly over and on top of the drums. A baffle plate is dropped about 6" below the inlet and uniformly distributed in the furnace. The surplus heat is then taken off underneath the floor and passes out under the furnace diagonally, making a super-heating furnace. Owing to the fact that the

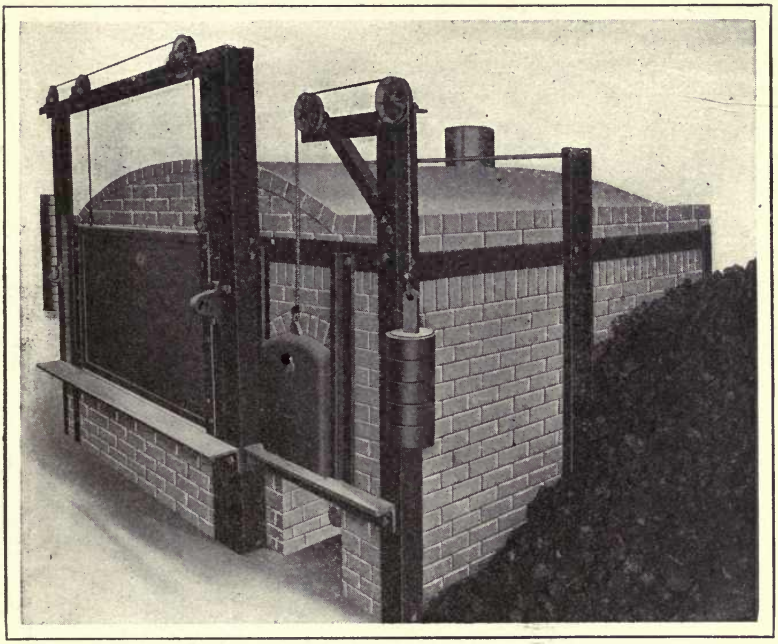

FIG. 102. VIEW OF COKE BURNING FURNACE OF THREE-DRUM CAPACITY

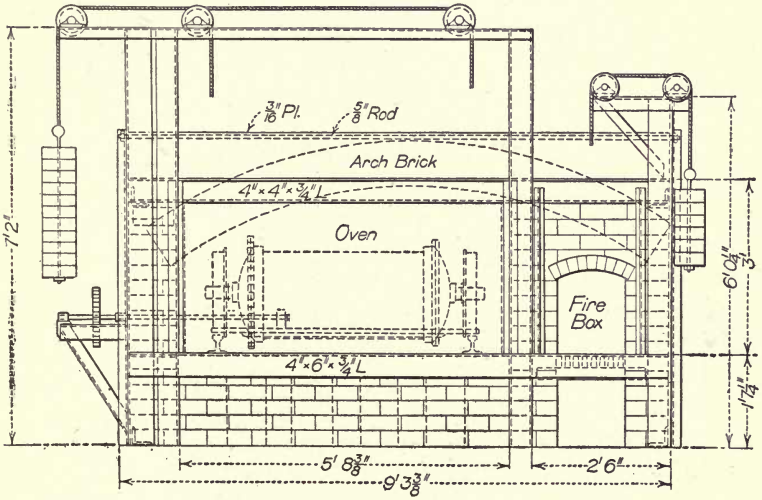

FIG. 104. FRONT ELEVATION OF THREE-DRUM COKE BURNING FURNACE

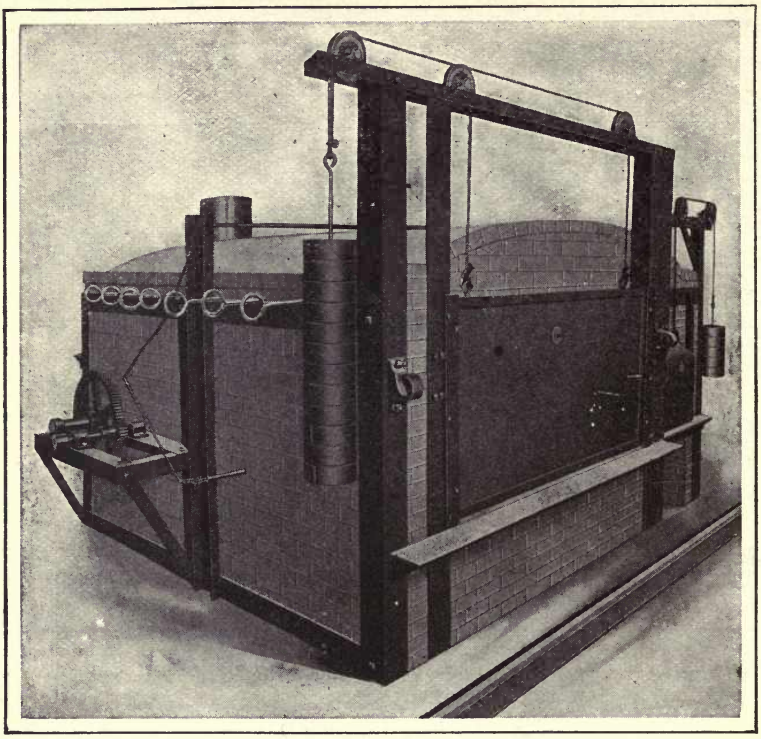

FIG. 103. ANOTHER VIEW OF SAME FURNACE, SHOWING OPERATING DEVICES

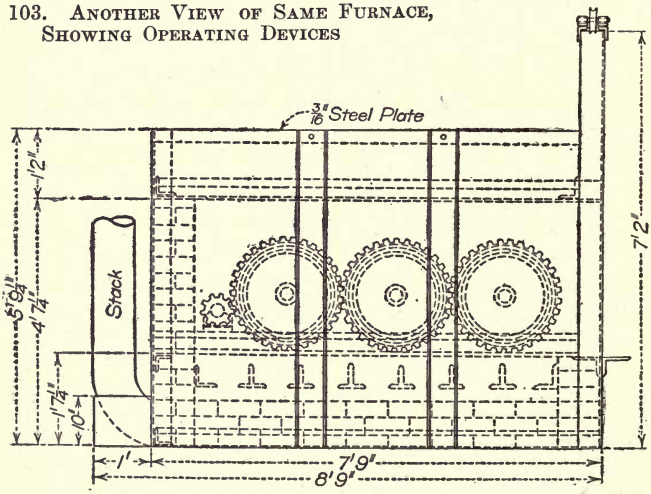

FIG. 105. SIDE ELEVATION OF THREE-DRUM COKE BURNING FURNACE

heat strikes the drums on the upper side, it has been found that the work must rotate more constantly than is necessary in a gas and oil burning furnace. Under these conditions it is necessary to have an automatic rotating device.

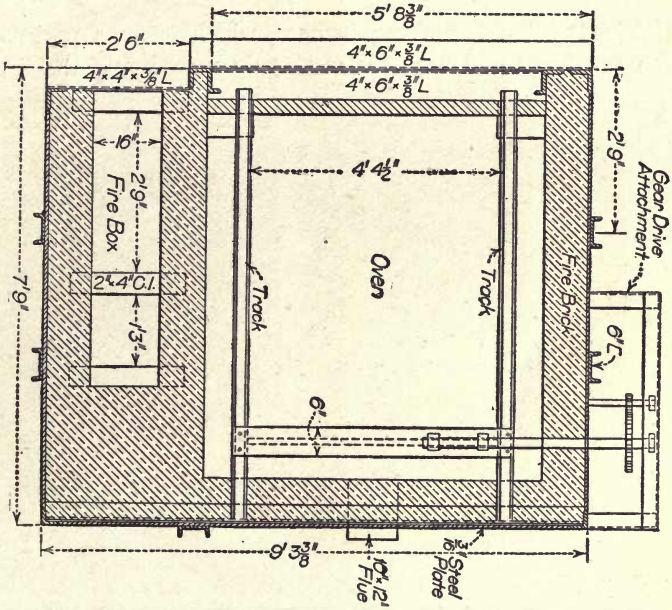

FIG. 106. SECTION OF THREE-DRUM COKE BURNING FURNACE TAKEN ABOVE FIREBOX

The details of construction are clearly shown in the elevations and sectional drawings given in Figs. 104, 105 and 106.

Single Drum Coke Burning Furnace

Fig. 107 illustrates a single drum coke burning furnace also built by Mr. Schoen. It is reinforced on three sides with steel plate, with an inner lining of 9 inches of firebrick and single arch. A feature of this furnace is that it can be grouted so as to bring the door proper in line with floor, which obviates the necessity of a transfer car. This also applies to furnace in Fig. 102. The grouting can only be done on the ground floor. The details of construction and general operation are clearly shown on the floor plans and elevations given in Figs. 108, 109 and 110. This furnace can be lengthened to eight feet long and operated uniformly from a three-foot firebox.

Note the drum turning device through furnace door. This was necessary through lack of room in rear of furnace at which point all rotating devices are generally attached.

Controlling Heat of Single Arching Furnace

Unlike the double arching furnace, which forms a pocket from which the flame and heat are uniformly forced into the furnace,

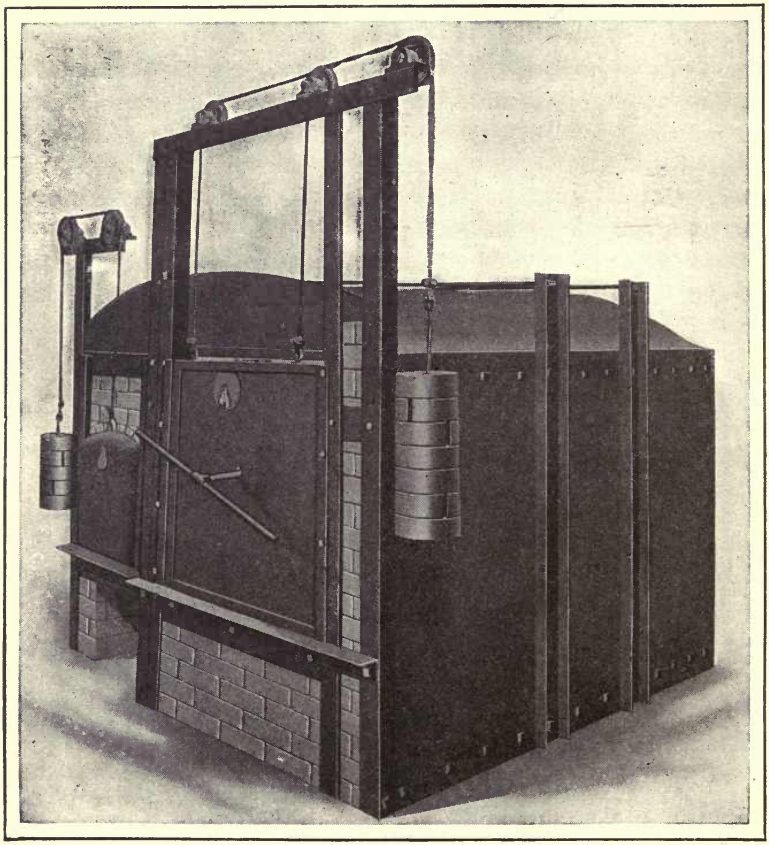

FIG. 107. SINGLE-DRUM COKE BURNING FURNACE

in a single arch furnace it comes directly over the inner wall as shown in Fig. 109, and the flame therefore has a tendency to go to the rear of the furnace even though the exhausts are at the front.

This is overcome by tapering the outlet or baffling the brick at various points. A baffle plate is attached to the arch directly over the drum to brake the flame and direct the heat so it will be uniformly distributed around the drum or receptacle.

Gas and Oil Burning Furnaces

Fig. 111 illustrates a small self-containing furnace built of structural iron and brick, with the cover attached by hinges, lined with

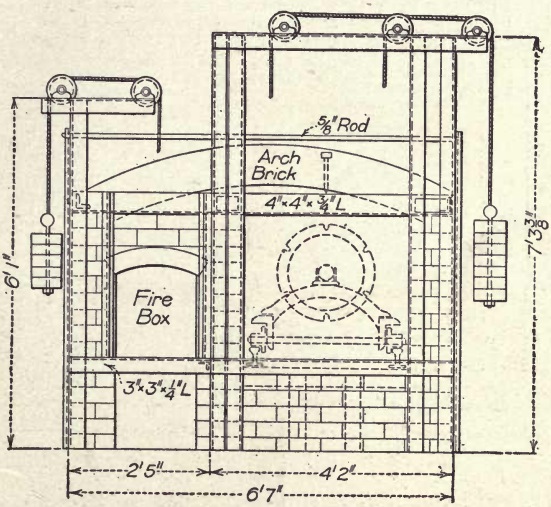

FIG. 108. FRONT ELEVATION OF SINGLE-DRUM COKE BURNING FURNACE

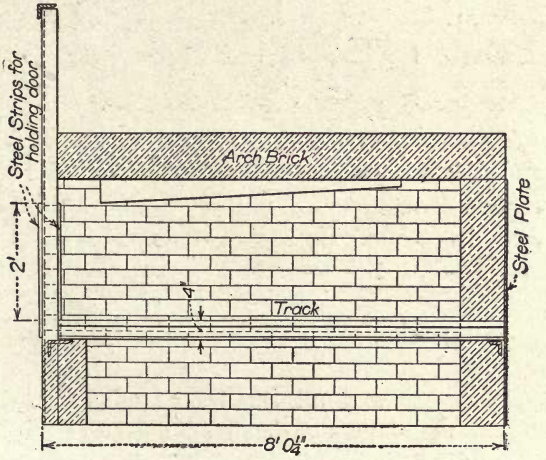

FIG. 109. SIDE ELEVATION OF SINGLE-DRUM COKE BURNING FURNACE

fire brick and fire clay on the inside for gas or oil burning. The material Sherardized in this oven would probably be bolts, nuts, washers, small malleable cast-iron articles, small

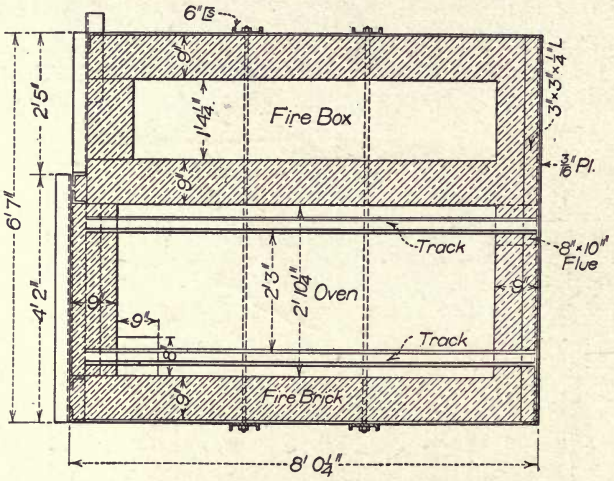

FIG. 110. SECTION OF SINGLE-DRUM COKE BURNING FURNACE

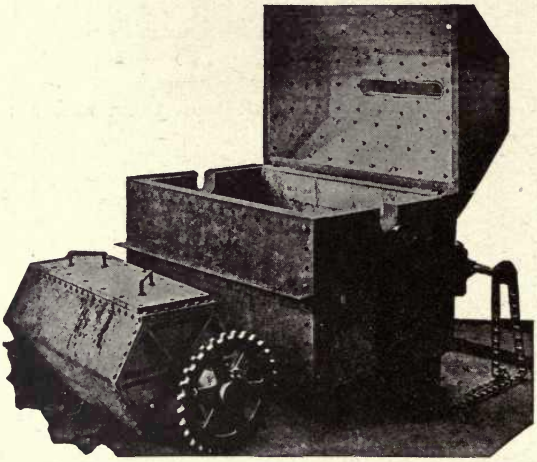

FIG. 111. A SELF-CONTAINED GAS FURNACE AND DRUM

castings and forgings and all small or medium sized iron or steel pieces that would pass through an opening 10 x 36 in. A special feature of a furnace of this kind is that it can be placed

anywhere in the factory and operated at very little expense, requiring no elaborate equipment in handling, and is very convenient even in the factories where large Sherardizing plants are in operation, due to the fact that small special work, which could not be

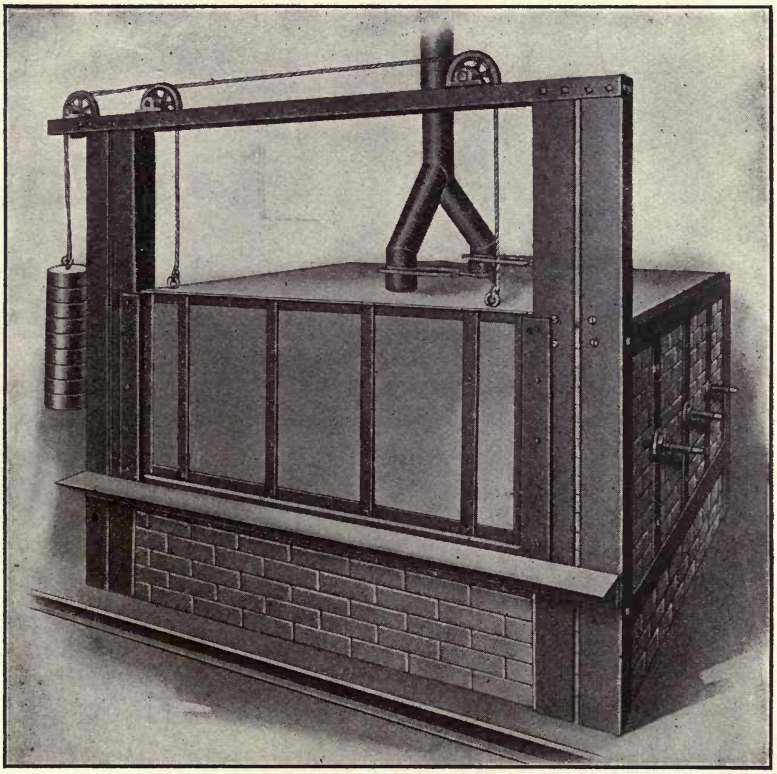

FIG. 112. GAS BURNING FURNACE USED BY NEW HAVEN SHERARDIZING CO.

run in furnaces where two and three cylinders were operating at one time, can be taken care of.

Fig. 112 illustrates the type of gas burning furnace used. This style of furnace is also operating successfully with natural gas, producer oil and fuel oil.

Figs. 113 to 114 are detailed sectional views of gas and oil burning furnaces. You will note that the only difference between the two furnaces is that the combustion chamber for the oil is more thoroughly reinforced at the floor lines, the combustion taking

place between the floor and the upper baffle bricks and coming out at the sides. The gas burning is an open flame directly against the drums, taking air from underneath the furnace, the air following along the burners. This applies where no pressure is used. In cases where gas is used under pressure then use the same equip-

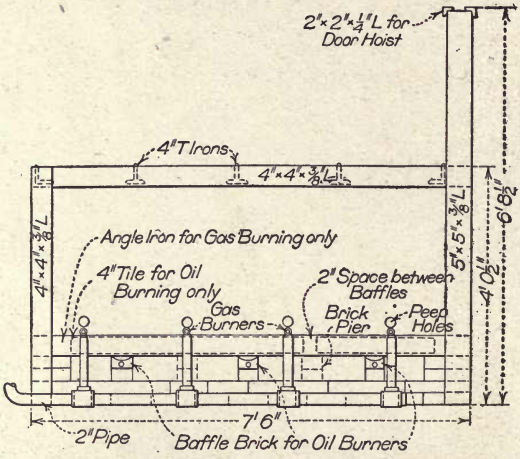

FIG. 113. SECTION OF FURNACE SHOWING DIFFERENCE IN REINFORCING OF COMBUSTION CHAMBER FOR GAS AND OIL

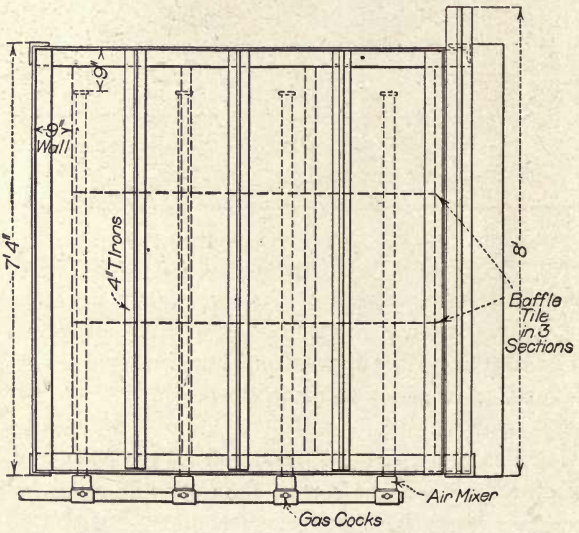

FIG. 114. PLAN OF FURNACE SHOWING ARRANGEMENT OF COMBUSTION CHAMBER FOR GAS AND OIL

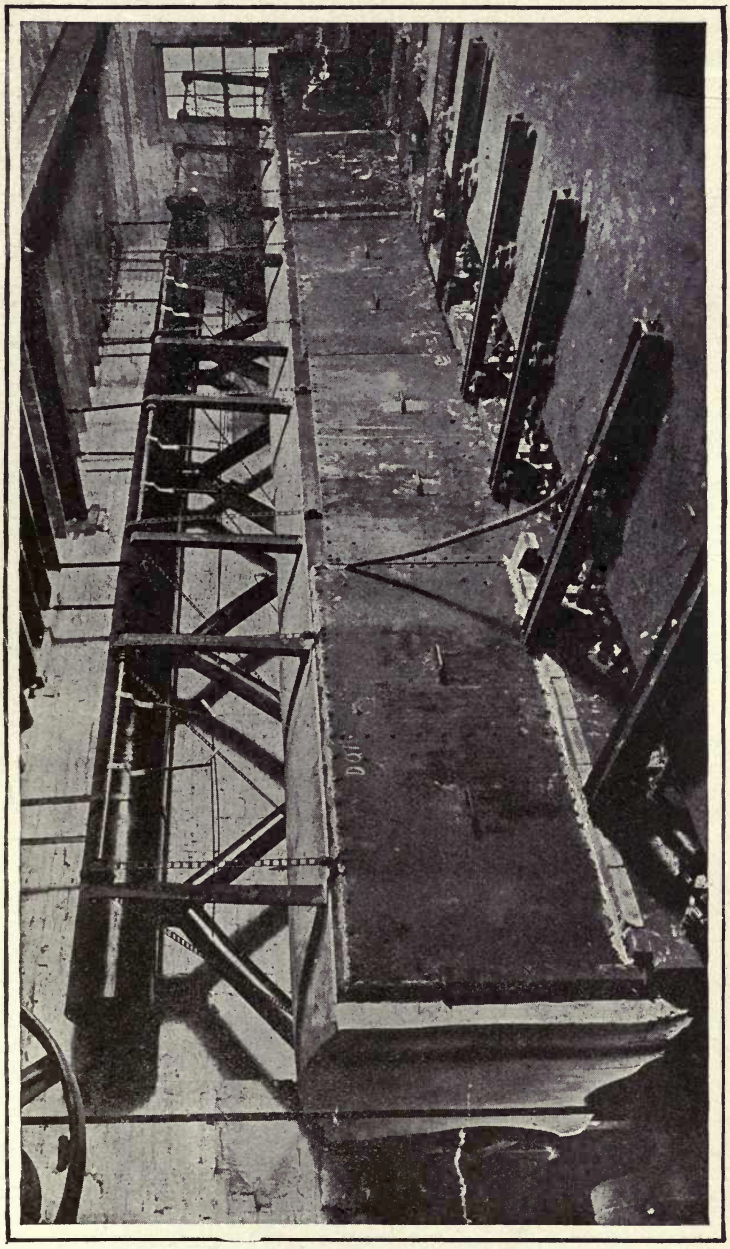

FIG. 115. A FIVE-COMPARTMENT FURNACE, TAKING DRUMS 18 x 60 IN. IN SIZE

ment as for oil, allowing more relief from the combustion chamber or a slight baffle which will distribute the flame uniformly.

As shown in Fig. 113, an angle iron is to be used for gas burning at that point only; for fuel oil, which gives off great heat and back pressure at intake, would quickly warp any metal parts and render it useless as a frame support. A tie rod at the floor line well protected with bricks is recommended.

Fig. 115 shows a furnace in the plant of the American Tap

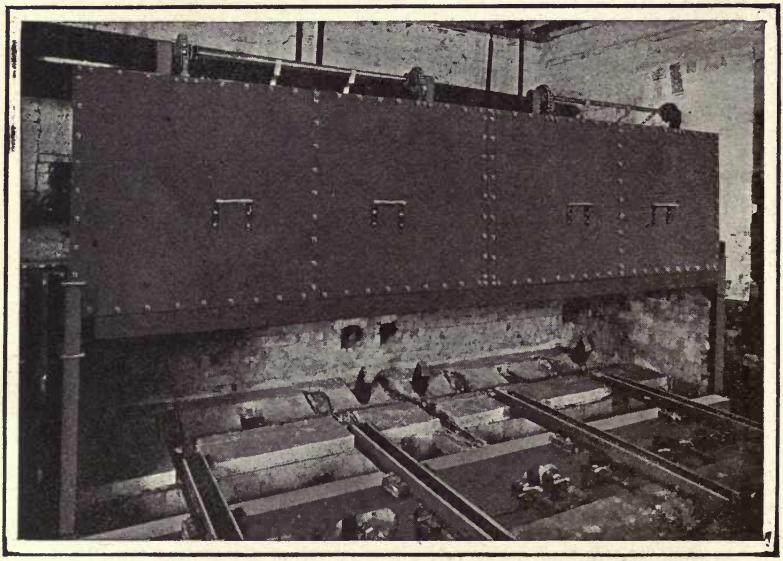

FIG. 116. TWO COMPARTMENTS OF THE FURNACE SHOWN IN FIG. 115 READY TO RECEIVE THE DRUMS

Brush Co., of Detroit, Mich., which has a capacity of twenty tons per day. The drums are 5′ long, 18″ in diameter, and the furnace is so built with separate chambers that, if the treatment of longer material was required, they would simply have to couple the drums together to any desired length. This plant would be a valuable plant to any one doing jobbing work and having a variety of material to be treated in different lengths.

Fig. 116 shows two compartments of the furnace ready to receive an 11½ ft. drum. It also shows the method of turning the drums and the combustion chamber.

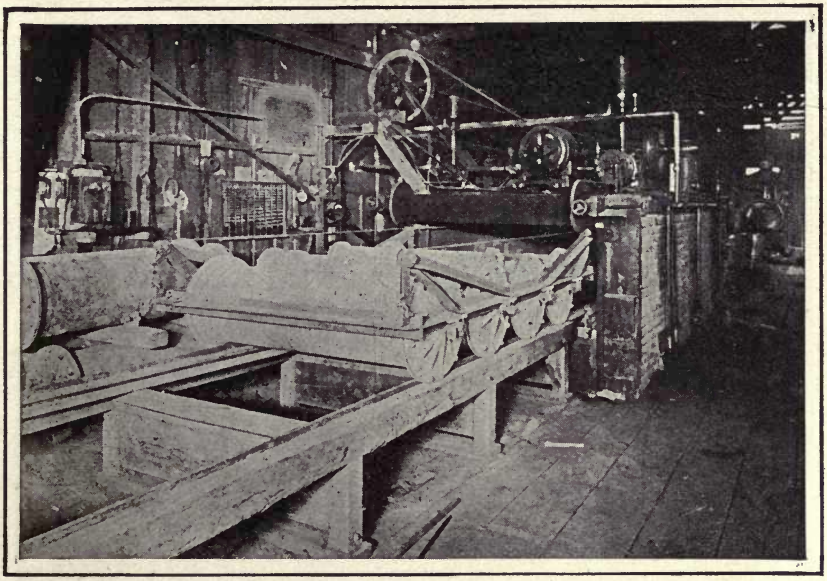

FIG. 117. A FUEL OIL BURNING FURNACE OF FOUR-DRUM CAPACITY

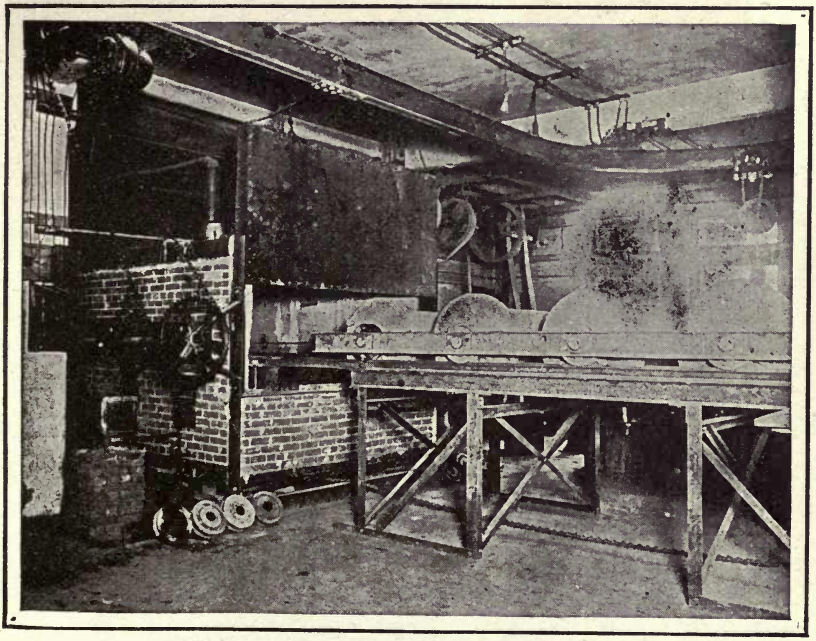

FIG. 118. TYPE OF OIL BURNING FURNACE

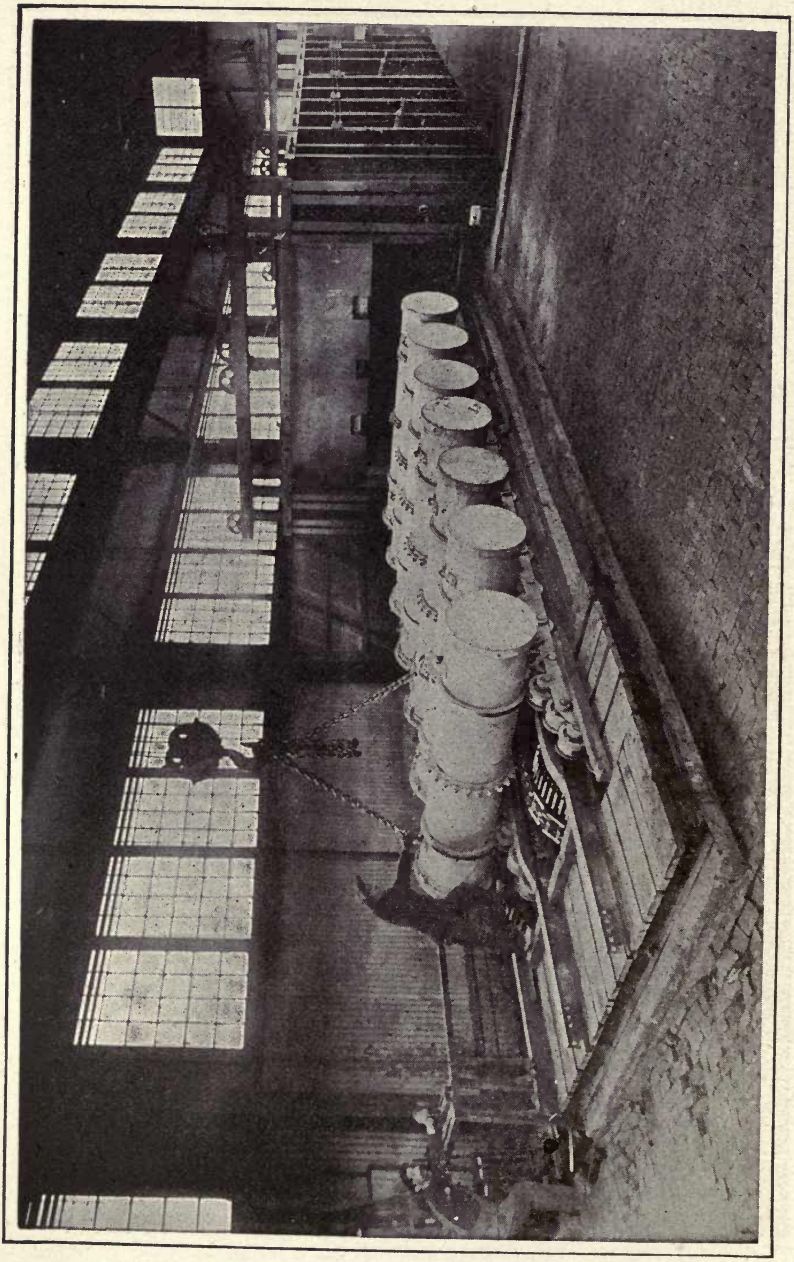

FIG. 119. VIEW OF LOADING END OF ONE OF THE LARGEST SHERARDIZING FURNACES IN THE WORLD

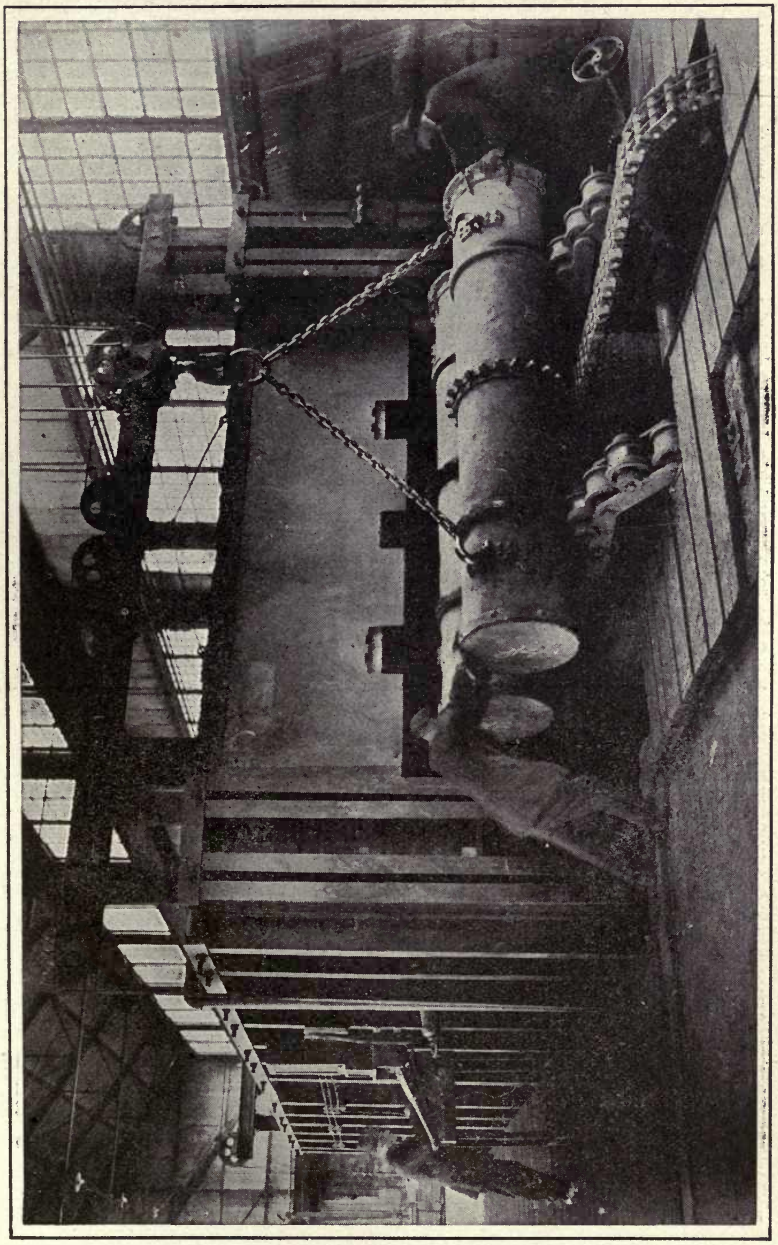

FIG. 120. ANOTHER VIEW OF THE SAME FURNACE, SHOWING COOLING PLATFORM

Fig. 117 is a view of the John Finn Metal Co.'s plant, in San Francisco. This is a fuel oil burning furnace of four drum capacity. The drums are rotated by a reciprocating movement of the carriage from one end of the furnace to the other. Considerable space could have been saved in this furnace by installing a pivot motion.

The pivot motion is shown in Fig. 118, which illustrates the type of furnace used by the Westinghouse Electric and Mfg. Company and the Union Switch and Signal Company. This furnace was installed for oil fuel, but there is no reason why it may not be used for gas, producer gas or natural gas. All that is necessary is to change the inside floor plans to provide the desired combustions.

Figs. 119 and 120 show the loading and cooling platforms of a furnace operated by the National Metal Molding Co., of Pittsburg, for treating conduit pipe and conduit fittings, and has a capacity of about thirty-five tons per day. This type of furnace is also recommended for water pipe and tubing. The drums are automatically taken into the furnace on very heavy chains and are automatically rotated with a sprocket attached to the center of the drum, the chain passing beneath with a continuous movement and protected from the flame.

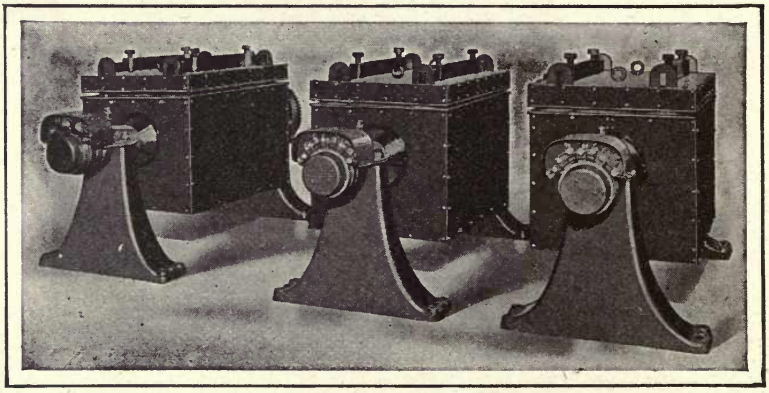

Fig. 121. Series of Electric Heated Sherardizing Machines

Electrically Heated Furnaces or Drums

A new departure in the Sherardizing field is the special type of electrical heated apparatus designed for the General Electric Co. This company coats considerable malleable iron and they are now

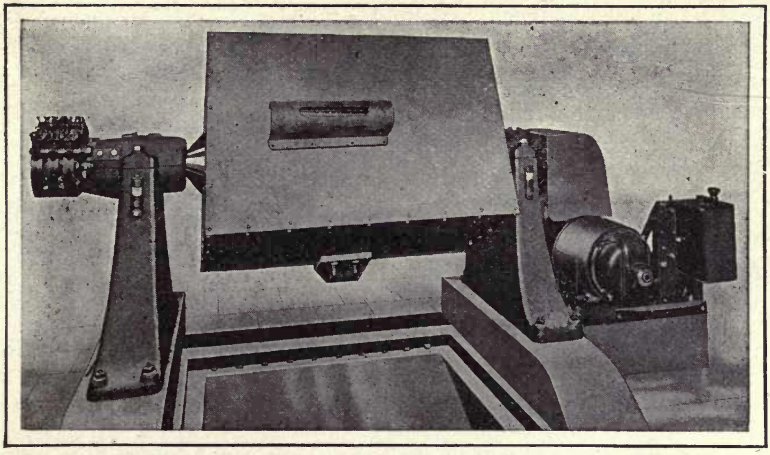

FIG. 122. 24" x 24" x 40" ELECTRIC HEATED SHERARDIZING MACHINE IN OPERATION

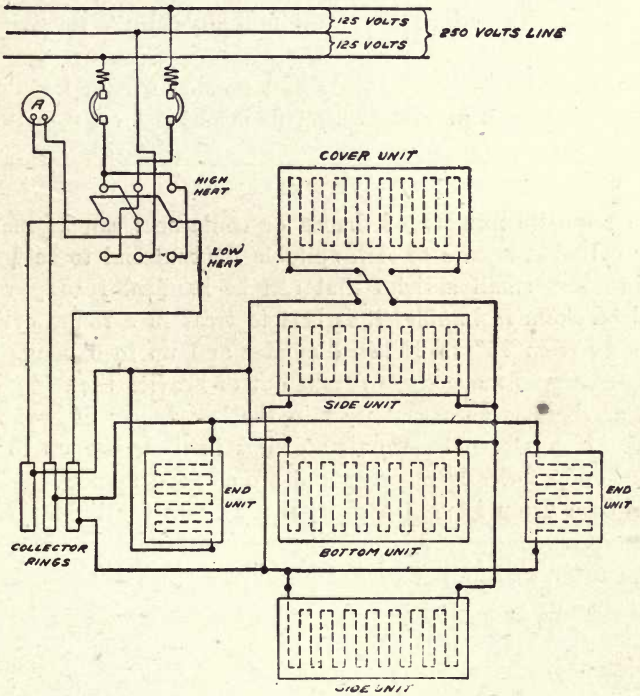

FIG. 123. LAYOUT FOR WIRING OF ELECTRIC HEATED SHERARDIZING MACHINE

using two sizes of machine; one 10" x 10" x 17" inside dimensions and requiring 15 kw. to bring up to the desired temperature and 5 kw. to hold correct temperature, and a larger one 24" x 24" x 40" inside dimensions requiring 50 kw. to heat up and 15 to hold at that temperature. The former is illustrated in Fig. 121 and the latter is shown with connections for heating in Fig. 122.

It will be noted that the machines are rectangular in shape and are revolved by a driving motor mounted on one of the pedestals and geared to the drum through a reduction worm gear. The heating elements are placed on each of the four sides and both ends of the machine, and the current is supplied to them through three collector rings at one end of the machine.

Wiring Diagram

The connections are such that the drum can be operated on a three-wire 250/125 volt D.C. circuit or a three-phase A.C. circuit. The only change necessary for a three-phase A.C. circuit is to leave off the wire leading to the bottom middle clip of the T.P. D.T. switch.

The general scheme of inside and outside wiring for the two drums may be seen in Fig. 123. This layout is for a 250/125 volt D.C. circuit.

Drums

The requisite number of drums or containers can be made in either cylinder, square or flat, suitable for material to be treated. For instance, small articles that can be handled readily with a shovel or chain in bundles it is best to treat in a round cylinder, averaging from 15" to 20" in diameter and up to 6' long. It is not necessary to make these drums out of heavier than ¼" boiler plate, as there is no actual wear in the low degree of heat maintained. It has been known that drums in *daily* use up to eight years show practically no wear and are as good as new.

A square drum is used a great many times for light material, and a top opening cover is recommended instead of an opening at the ends. This will allow perfect packing, so that when the articles are taken out they will not be bent or warped. It is, however, recommended that drums not over 20" square be used on such light material to insure uniform penetration. In the case of flat stock for panel work, etc., a flat drum of not over 16" in depth is recommended, as the stock, being flat, will lie very closely and it

would be impossible to get a perfect, uniform coating if the diameter was increased. The length and width make no difference.

Fig. 124 illustrates a cylinder drum 15″ to 20″ in diameter, made of ¼″ boiler plate, welded. The flange and head are cast or malleable iron and are machined to make a dust proof fit. There is one feature that deserves special attention. It is the use of slotted parts instead of holes for fastening on the heads. Ordinarily the bolt will expand with the heat to such an extent that it is impossible to remove the nut, but with the above arrangement the bolt can be removed without injury, or where the nut will not come off it will loosen sufficiently to work out of the slot.

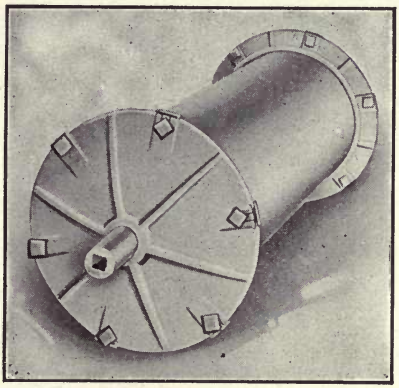

FIG. 124. A CYLINDER DRUM

Dust Separating Machine

Fig. 125 gives a sectional view of a dust separating machine. This screener, which is known as a cylinder screener, is made of structural angle iron, 2½″ x ¼″, and matched boards, thoroughly reinforced, and the screen is made of perforated metal. The work is received at one end, the dust dropping through into a receiving box and the material coming through at the other end free from dust. It has been found, in a good many instances, that on flat stock or cup-shaped material the dust is not all relieved at the first screening, in which case a conveyer is made of two pieces of 5″ x 5″ angle iron and a carrying belt is placed on the receiving end of the screen and conveyed to another screening machine of the same type, which will relieve such zinc as has passed through the first screener. A conveyer of

this type is very easily constructed and inexpensive, and saves a lot of shoveling and handling. The gear pattern is so arranged that it can be operated with worm drives.

Fig. 125 illustrates the style and make of dust separating machine used. This screen can be placed anywhere on the floor, no pits or conveying device necessary. The machine will hold about three thousand pounds of zinc at one screening.

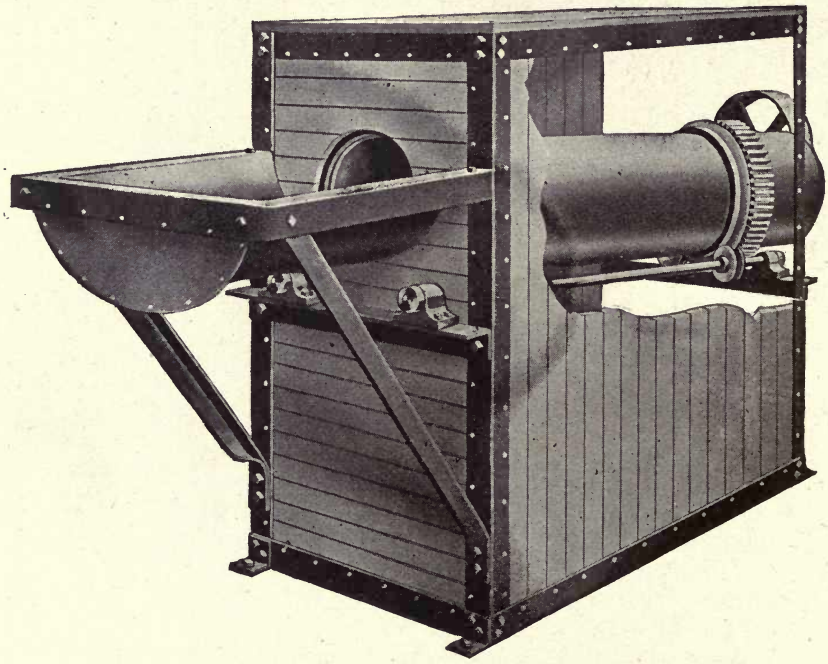

FIG. 125. DUST SEPARATING MACHINE

Mr. Schoen of the New Haven Sherardizing Co. has spent a number of years perfecting this machine, and believes that a machine of this type should be part of the equipment of every plant, for it is inexpensive and turns out clean work. An exhaust hood should be attached to carry all zinc residue to the reclaiming box.

Fig. 126 shows this same screener in operation, receiving the work from the drum; also a hood placed in such a position that the light zinc dust, which is bound to fly, is taken care of under a slight suction. The drum is conveyed by means of an overhead trolley. The head is removed from one end of the drum and the material is

dumped into the hopper. The screen revolves about forty revolutions per minute, the dust dropping through into the receiving box below and the material coming out at the other end. A hood is

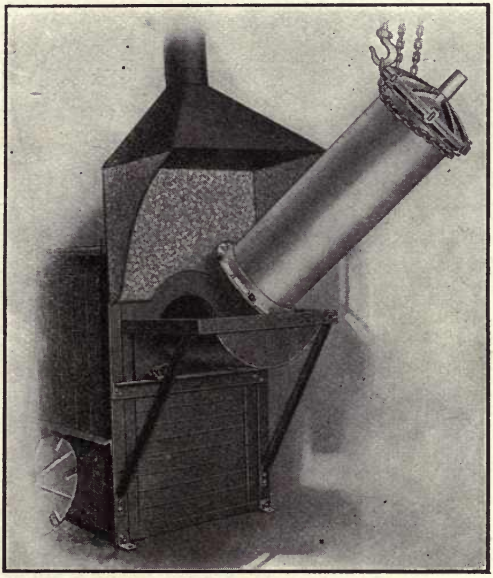

FIG. 126. DUST SCREENER IN OPERATION

placed over the receiving hopper at the end where the material comes out; an exhaust is attached with enough suction to take care of whatever dust may escape. This is exhausted into a canvas-covered box and saved.

The Transfer Car

The transfer car is not of any special make. It is merely used for transferring drums from one place to another and can be easily built from structural iron with a few cast-iron wheels and bearings, thoroughly reinforced. Generally speaking, these are specially manufactured to meet the requirements of different plants. Fig. 127 shows one type of truck used. The "I" beam is standard, generally using the very lightest, as the weight ordinarily carried in one of these drums is not over one ton.

Fig. 127 also shows three drums placed in position and secured by a locking frame, which keeps the drums the right distance apart and transforms same into a track. They are standard cylinders

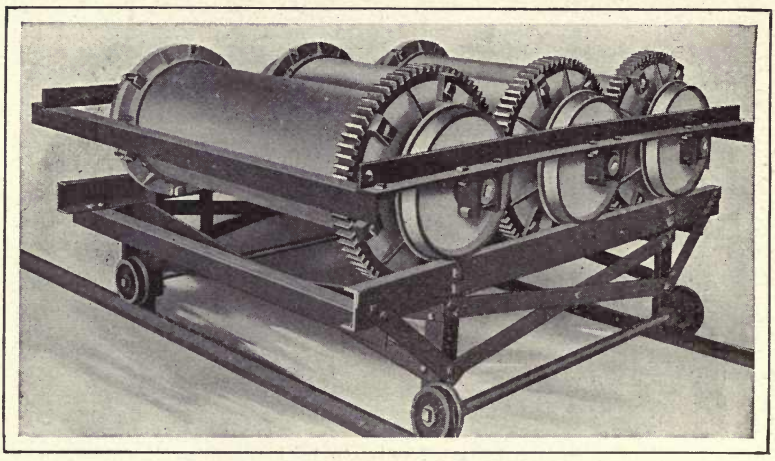

FIG. 127. TRANSFER CAR AND DRUMS

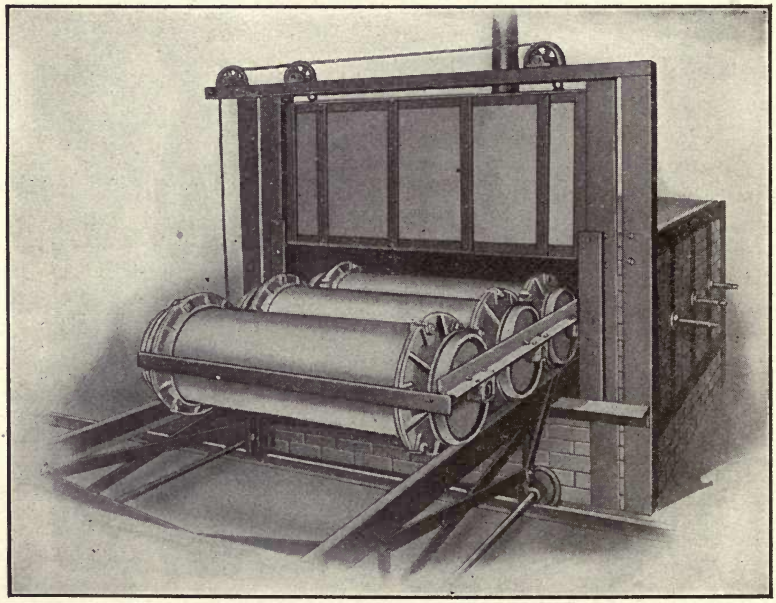

FIG. 128. ROLLING DRUMS INTO FURNACE AS A UNIT

with gears attached to drum heads. The driving gear coming at the rear end inside of the furnace, as shown in Fig. 103, turns all three drums uniformly, as they are all interlocked. These can also be operated individually without gears, as shown in Fig. 128.

NOTE.—The wheels placed loosely on the hub act as a bearing and truck. This method is recommended, as it obviates the necessity of using heavy structural iron trucks, which mean an additional expense for heating of additional iron and also the trouble of keeping the truck from warping.

Fig. 128 illustrates furnace receiving drums from the transfer car.

This operation is handled mechanically by a pulling device at the rear of the furnace; but as extra large bearings are used, one man can easily push the drums into the furnace: In case of individual rotating or turning the stems as shown are then pushed into the hub of the drum, which also holds the drums in position. With gear drive they are locked into position with a clutching device on the track at the front of the drums.

Cooling Frames

Cooling frames need no special specifications. Two pieces of railroad track or channel iron, mounted so that they meet the transfer truck, are all that is necessary.

Pyrometers

Every furnace should be equipped with a pyrometer, which is placed on the wall in the operating room, a certain distance away from the furnace, and thoroughly protected in a dust-proof case. The leads can be bought any length to go with the instrument, and are always standard. Recording instruments are highly recommended. Chapter III gives special attention to pyrometers.

CHAPTER XXVI

Materials Used in Sherardizing

CONCERNING the practical side of Sherardizing, the article to be Sherardized must be regarded, first, in respect to its ability to absorb zinc vapor, and then the condition under which zinc produces vapor at the highest tension.

The articles to be Sherardized are almost exclusively of iron in its different stages and forms, as cast iron, malleable iron, wrought iron, cold-rolled steel and steel in all its stages. Many kinds of iron articles have to be dealt with in many forms and stages and quite naturally they would have different rates of occlusion, due to the nature of the structure and form and quality of surface. The articles to be Sherardized cannot be selected to any extent and the specifications under which the articles are being made cannot be changed without affecting their cost. Therefore, the most favorable condition under which the given article will absorb the most zinc vapor must be obtained. In some cases it will be a selection of temperature or pressure; in some cases it will be the treatment of the article, as annealing, or annealing under a reducing atmosphere, and in some cases, in the treatment of the surface mechanically (sand blasting and tumbling), or chemically (pickling).

In the theoretical discussion, mention was made of the effect of temperature as an important factor to both elements of the process. In this connection it would be well to note that a critical point exists for the articles Sherardized, for not all articles to be Sherardized could be heated to the same degree without changing their physical properties. From this we see that the definite temperature for each special condition must be determined, which is best for both the zinc dust and the treated article.

The material used in the process of Sherardizing is commercial zinc dust, commonly called blue powder, of which, at this time, about 90% is imported and which, as an average, runs from 75% to 90% metallic zinc. Grasselli zinc is also used, but mostly in keeping up the strength after the zinc has been reduced to a low percentage. This is made from ground spelter and must be run

at a much lower degree of heat than the blue powder. Zinc dross is also used, but not very successfully, as it will not alloy itself with the work as thoroughly as the finely powdered zinc, although when the two are combined in equal parts they show very good results.

Dust from the Zinc Smelter

There are two kinds of zinc dust on the market for commercial purposes, Grasselli and common blue dust. Blue dust is a by-product of a zinc smelter and is mostly imported from Belgium and Germany. Grasselli dust is manufactured in this country from metallic zinc. The zinc dust should be kept dry, and if new zinc dust is used it should be dried out for several hours in the Sherardizing drums at 100 deg. C., slowly rising up to 250 deg. C.

The blue dust can be used with a lower metallic percentage. Less time is required for the run in the oven (5 to 6 hours). The quality of coating is better, as it is more uniform and solidified. Black spots are practically eliminated. There is no danger of fusion, bailing, balling, and caking, irrespective of the various high temperatures. High temperatures can be used.

The drums, however, cannot be opened when using blue dust until a relatively low temperature has been reached, due to the very quick oxidation and danger of ignition. A longer period is therefore required for cooling. There are difficulties of handling this dust without a proper ventilating system and adhesion of loose dust to threaded and knurled surfaces occurs.

Freeing Dust from Iron

The dust is run through a magnetic separator at least once every four weeks to take out superfluous small particles of iron which are liable to become lodged between the jaws of cotter pins, etc., and thus cause trouble in assembly. By cleaning the dust this way the mechanical incorporation of large percentages of iron dust in the coating is also prevented. It is recommended that the weekly analysis of working dust show the iron content.

The Use of Manufactured Zinc Dust

A brighter metallic coating is obtained than with the blue dust. Less time is required for cooling and less danger is encountered in opening the drums when hot.

A higher metallic percentage is, however, necessary and a longer

time is required for the run in the oven. There is also danger of fusion of zinc due to slight overrunning of temperature.

Method No. 1 for Determining Metallic Zinc in Zinc Dust

Into a 400 c.c. Erlenmeyer flask weigh 10 grams of zinc dust, to be investigated. Measure 10 c.c. of metallic mercury into same, add 100 c.c. of boiling hot water, and run into same from a burette the excess of standard normal HCl, the amount added depending entirely on the oxide contents of the dust under investigation. (From 30 to 50 c.c. usually suffices unless the dust is unusually high in oxide.) After the excess of acid is added, as shown by methyl orange, insert a stopper and shake for several minutes until the metal is completely alloyed, and the oxide is dissolved, with the exception of a small amount of coal dust and insoluble matter which usually accompanies such products After the solution is effected, decant off the liquor from the mercury alloy, wash the alloy by decantation in the flask, and titrate the excessive acid with standard normal soda solution until same is exactly neutral, as shown by change of indicator, as well as by faint precipitation of zinc in solution; calculate the percentage of oxygen (1 c.c. of normal HCl being equal to .008 oxygen) from which the zinc oxide can readily be calculated.

1 c.c. $N_2HCl = 0.0203$ gram zinc oxide

Per cent. of metallic zinc = 100% less % of zinc oxide

Method No. 2 for Determining Metallic Zinc in Zinc Dust

Weigh out exactly 0.2939 g. of dust and introduce same in a 200 c.c. Erlenmeyer flask. Add a piece of Pt. foil as a catalyte. Add 30 c.c. water. Put 10 c.c. conc. H_2SO_4 into a small bottle and lower same into flask without spilling.

Connect up flask to gas burette. Invert flask enough to mix acid with water. After standing for 3 hours, read off on burette number of c.c. hydrogen generated by action of acid on zinc. Make correction for temperature. Number of c.c. gives per cent. metallic zinc.

If, after having determined the proper conditions to get the correct results in Sherardizing, these conditions are held to during the operation, the results will be constant. If these conditions are allowed to vary beyond reasonable limits, then the product will vary, and the Sherardizing will be irregular.

It is my belief that these impurities have little or nothing to do

with the properties of zinc dust and that the reason should be sought for it in its mode of production.

Method No. 3 for Determining Metallic Zinc in Zinc Dust

To prepare permanganate of potash titrating solution (it is not a clarifying solution) weigh out 5 g. of pure fresh permanganate of potash crystals—weigh accurately—dissolve in 500 c.c. of pure distilled water at 60 deg. F. or thereabouts, i.e., upset the crystals into a dry glass-stoppered flask and then fill up with water to the 500 c.c. mark. Do not put the water in and then the crystals afterwards, which would make the solution one or two per cent. too weak. Place glass stopper in position, shake well till dissolved and then store in a dark cupboard. It will keep for about a fortnight or so, but for competitive or buying or selling samples, where extreme accuracy is wanted, always make up a fresh solution.

Weigh out from a previously carefully selected sample of zinc dust, 1 g., weighing same to a hair; suspend in about 2 in. of distilled water in a glass beaker 3″ in diameter—beaker large enough to hold a pint. Add to this 12 to 20 g. (according to presumed metallic value of dust) of pure ferric sulphate, and stir it and grind it with a glass rod for 20 min. off and on till all the zinc dust and all the ferric sulphate is dissolved with the exception of a few possible impurities at the bottom. Test these, however, by grinding them with the glass stirring rod and hold beaker up to a strong light and looking through it from the bottom and if any action (bubbling or movement) is seen on these impurities, give the solution a little more time to dissolve them. Then add another inch or so of pure water to save intense heat when acidulating, then add 25 c.c. strong sulphuric acid C. P. (for ordinary shop work good soft clean tap water if free from organic matter, and good quality commercial acid will do). Stir the acid in.

Before adding the acid the solution is of a rusty orange color. After adding the acid the solution is of a light emerald color.

Having done this, take a 100 c.c. graduated measuring glass tube, with a cock at the bottom, i.e., about 9½″ high and 1⅛″ or less in diameter and graduated by centimeters from 0 to 100 c.c., and fill it up to the 100 c.c. mark with the permanganate of potash solution.

Gradually pour this into the zinc solution. At first the pink color will almost instantly disappear, then go slower and hang

cloudy. *Keep stirring* all the time until the end, i.e., when the last drop or two added and well stirred will just turn the whole solution throughout a pale salmon pink. Then stop. Read off from the glass how much of the solution was used and multiply this by 1.0364. The result will be the actual metallic percentage of the zinc dust.

Example: 49 c.c. of solution used to give the pink color. Then $49 \times 1.0364 = 50.7836$ per cent. metallic zinc. Thirty to 40 per cent. dust will do with 12 to 15 g. ferric. Over that make sure by giving it 20 g. ferric. *Excess does not harm.*

CHAPTER XXVII

Preparing Material and Loading

THE methods described in the preceding pages of this book, for cleaning castings and other material for hot galvanizing and tinning, are also applicable to material for Sherardizing, with the following exceptions. When cleaning with acid by the pickling process, the acid should be thoroughly relieved.

If a sufficient amount of cast and malleable cast iron are handled it might be advantageous to use a sand blast for removing the dirt, rust or slag, but when castings form only a part of the work they can be treated according to the following specifications.

Cleaning material by sand blasting is accomplished by subjecting the material to the impact of fine, clean, dry sand under air pressure of 20 to 80 pounds. If the work to be cleaned consists of large pieces that can be handled easily, hose about ¼ to ⅜" is used. If the material consists of small articles it is more economical to use a sand blast tumbling barrel. The advantage of cleaning material by this method is that all slag or silica scale is quickly removed, exposing the clean iron. It also overcomes the use of acids, etc., which are very hard to eliminate in porous or bad castings. A comprehensive treatment of sand blasting and cleaning in the tumbling barrel is given in Chapter VI.

Pickling of Steel

In pickling steel, such as bolts, nuts, washers and scaly material, the articles should be thoroughly washed in the lye solution, the strength of which must be about 38 pounds of lye to each 100 gallons of water. Care must be taken that no washed-off oil or fat is allowed to float in the tank, and skim as frequently as possible. When the solution becomes greasy or brownish in color, it should be renewed. If the tank is to be kept busy, the renewal should take place every other day. Keep the material in the solution from 5 to 10 minutes, and drain in the basket. If the material is covered with dried-out oil, it should remain in the solution for a longer time.

Wash in hot water and drain.

Place in the hot sulphuric acid solution long enough until all foreign substance has been removed or dissolved (in some cases 5 to 8 minutes). The strength of this sulphuric acid solution should be about 9.5 per cent., in which 13 gallons of 66 per cent. commercial sulphuric acid solution should be used to each 76.5 gallons of water. The pickling qualities of this solution can be determined by its density and its color. A hydrometer should be used and the solution should be about 1.115 at 38 deg. C., or about 1.110 at 80 deg. C. If the solution should happen to be clear and its density less than the stated value, acid should be added to maintain its strength. If the color of the solution changes and appears brownish, the solution becomes invalid and should be renewed. Drain the material in this solution.

Wash in hot water and drain.

Place in a lime solution, which will neutralize any acid that still remains on the material. The strength should be about 20 pounds of either quicklime or air slacked lime to each 100 gallons of water. When the solution changes from a milky to a brownish color it should be renewed. The material should remain in this lime solution for at least 5 minutes and then drain.

Wash in hot water and drain. From time to time litmus tests should be made in this water tank, and when the water shows acid reaction it should be renewed. In case flaky sediments occur in this tank, it is advisable that the drain be opened at different periods to remove them, since they are heavier than water and cannot be washed out by the inflowing water. Usually the tank may be drained twice a day.

Empty the material on the inclined screen for drying.

The temperature of the acid and alkali solutions should be 60 deg. to 80 deg. C.

The temperature of the water baths should be 70 deg. to 90 deg. C.

Fresh running water should be allowed to enter each water tank in order to keep it clean.

Before each renewal of either water, acid or alkali solution, the tank should be thoroughly cleansed.

During the pickling process the baskets of material should be shaken and dipped several times into the solution in order that the tightly placed material may be benefited by it.

Pickling Malleable and Gray Iron Castings

Malleable iron line material should be thoroughly washed in the lye solution, the strength of which must be about 38 pounds of lye to each 100 gallons of water. Care must be taken that no washed-off oil or fat is allowed to float in the tank, and skim as frequently as possible. When the solution becomes greasy or brownish in color, it should be renewed. If the tank is to be kept busy, the renewal should take place every other day. Keep the material in the solution for 5 to 10 minutes, and drain in the basket. If the material is covered with dried-out oil, it should remain in the solution for a longer time.

Wash in hot water and drain.

Place in the hot hydrofluoric acid solution long enough until all foreign substance has been removed or dissolved. The strength of this solution should be about 5 per cent., in which 15 gallons of 30 per cent. commercial hydrofluoric acid should be used to each 76.5 gallons of water. The pickling qualities of this solution can be determined by its density and its color. A hydrometer should be used and the solution should be about 1.026 at 15 deg. C., or about 1.009 at 80 deg. C. If the solution should happen to be clear and its density less than the stated value, acid should be added to maintain its strength. If the color of the solution changes and appears brownish, the solution becomes invalid and should be renewed. Drain the material in this solution.

One of the cheapest and most used methods of relieving the acid is by rinsing in cold water and then placing the material into a boiling solution of cyanide (mixture: 1 pound of cyanide crystals to 20 gallons of water) for ten minutes. Material coming from the ordinary pickle placed through this method will insure the relieving of all acid. By following this method a bright, clean coating of zinc is assured.

Cup-shaped material should be stacked in the basket in such a way as to contain as little acid as possible. In case the material should show defective pickling or rust, it should be repickled. In case the defects are slight, sand tumbling can be applied for 10 to 15 minutes. The material should be put into the Sherardizing drum as soon as possible after pickling, to prevent oxidation.

Loading the Drums

Alternate layers of zinc dust and material should then be placed

into the container within a few inches of the cover to allow for any expansion that may take place From 3 to 5 pounds of zinc dust should be used to each 100 pounds of material. The cover should be made dust tight, not air tight, and the container then removed to the furnace.

Fig. 129 shows method of loading a drum up to 6 ft. long. The steel loading frame is placed in a dusting pan to catch whatever dust may be scattered and lost. The drum is placed on a loading frame at an angle of 45 deg. The material is then shoveled or placed in the drum with a thorough mixture of zinc, averaging on bolts and

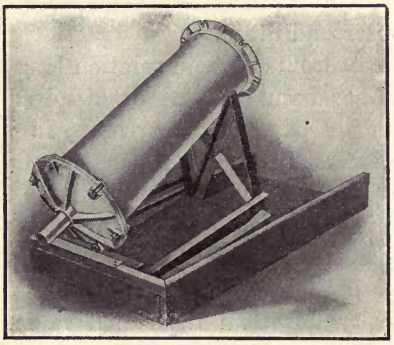

FIG. 129. DRUM IN POSITION FOR LOADING

nuts 100 pounds of zinc dust to 200 pounds of material. After completely filling the drum, the head is placed in position and secured. The cover should fit so as to be dust proof, but not air tight, so that whatever gases form within the drum will come out and burn during the operation. The wheels are then placed on the hubs and the drum placed onto a transfer car. Care should be taken in seeing that the horizontal axis of the drum is in line with that of the clutch which revolves it, thereby causing a true rotation of the drum; also that the carriage should be firmly held within the furnace by means of lock keys. Heat should then be applied.

Another method of loading is to alternate the zinc dust and material and only fill to within 6" of the top.

Fig. 130 illustrates the method of loading from overhead chute. This method is highly recommended in cases where pipe, tubing and articles are Sherardized up to 20 ft. long, which require a coating on the inside as well as the outside. One particular item should

not be overlooked in the conveying of the zinc dust into the chutes and hoppers. Due to its density it will pack very close and a worm feed is found necessary to transfer it uniformly from the hopper into the drums. The dust used is obtained from the hoods of zinc smelters, upon which it is formed by the condensation of zinc vapors, and it is not ground commercial zinc, as has been

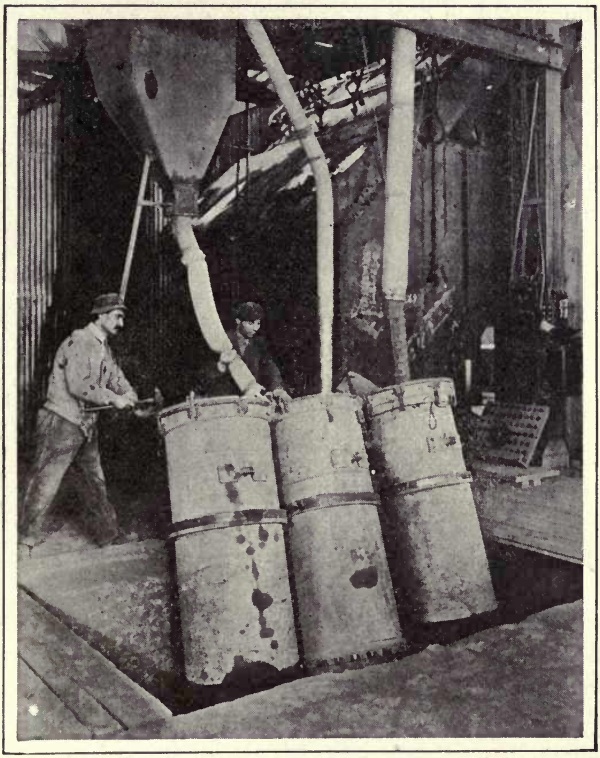

FIG. 130. LOADING FROM OVERHEAD CHUTE

erroneously stated. The dust usually contains about 85 per cent. pure zinc and 10 per cent. of zinc oxide, which latter is not in a free state, and, being evenly distributed throughout the mass, prevents the dust from becoming pasty at the high temperature required for Sherardizing.

In loading flat stock it is necessary to have a layer of zinc between each piece of metal, uniformly distributed, and the drums should be rotated the same as the cylinder drum.

As zinc dust is one of the main features in producing good

results in the process of Sherardizing, special attention should be given this item. It should be procured free from lumps and with as little moisture as possible, and stored in galvanized cans and kept covered when not in use.

In case the zinc dust is damp and lumpy, it should be placed in the cylinders, without any material, drums filled about one-half full, and the cover lightly fastened to assure relief of accumulating gases, and placed in the furnace at about 350 deg. F. for three hours. The zinc dust will then be in perfect condition for use, after cooling.

The best results are obtained when the zinc dust has been reduced to about 50 per cent. metallic, and therefore new zinc should be reduced to that percentage as rapidly as possible.

Sherardized material shows a deposit of 4 pounds of zinc per 100 pounds of material treated, as an average. Therefore, once it has been reduced to the right percentage, it can be held at that strength by simply adding 4 pounds of new zinc per every 100 pounds of material treated. See that it is thoroughly mixed. A chemical analysis once a week is recommended.

The above stated deposit is sufficient to stand the well-known Preece test of four one-minute immersions in saturated solution of copper sulphate, U. S. Government and Western Electric Co.'s test, specification No. 13110, dated February 3, 1908.

Packing the Electric-Heated Machine

Material must be packed in drum in such a way that no violent tumbling will occur, else sharp corners or threaded parts will be damaged; neither should it be packed too tight, or a free flow of dust and heat will not result and, consequently, poor Sherardizing will be obtained. By actual experience in Sherardizing malleable iron, which is very porous, it has been found that 400 lbs. of dust to any load, ranging from 400 lbs. to 1,800 lbs. of material, can be used. This consists of 360 lbs. of used dust and 40 lbs. of new Grasselli dust. When small material is packed in individual receptacles to be placed inside of Sherardizing drum, a proportion of about 5 lbs. of dust to 100 lbs. of material is used. The dust should be mixed in a tumbling barrel or Sherardizing drum and sifted through an 80:1 mesh riddle before charging the drum.

Before putting cover on drum an asbestos wicking basket is put under cover to make drum as nearly air tight as possible.

CHAPTER XXVIII

Temperature and Duration of Heats

TEMPERATURE and time are factors which, depending upon each other, are very important in the process of Sherardizing. They depend on the choice and quality of zinc dust used and also on the requirements and physical properties of the Sherardized material.

If common or blue dust is used, the total run is to be about 5½ hours, of which about 2 hours must be allowed for attaining a maximum furnace temperature of 440 deg. C. and about 3½ hours for a temperature of 440 to 450 deg. C. The metallic percentage of zinc should be from 35 to 45 per cent. The drum should be rotated throughout the whole run at about ½ r. p. m.

In case Grasselli dust is used, the strength should be 40 per cent. and upward. The total run should be 9½ hours, of which 2 to 2½ hours must be allowed for attaining a maximum furnace temperature of 385 deg. C. and 7 to 7½ hours for a temperature of 385 deg. C. The container should be rotated the same as for blue dust.

At the end of the run the container, if blue dust is used, should be removed from the furnace and not opened until the temperature has dropped to 100 deg. C. This will require 8 to 24 hours, depending upon the outside temperature. In the case of Grasselli dust the container can be opened at a somewhat higher temperature. No cooling must be done by application of water or moisture.

Thickness of Coating

Careful attention must be given to see that the dimensions of articles, as bolts or nuts, should be such as to allow for enough clearance for the various kinds of coatings. These dimensions, where in normal cases the test is from 4 to 8 dips, should have an allowance for a coating of 0.001″ to 0.002″. For example, if a pin for drive fit is to be Sherardized, the difference in diameter between the pin and hole before treatment should be 0.006″ to 0.008″ if both surfaces are Sherardized.

The General Electric Co. in Sherardizing their material deposit

.0025" on a side or a total of .005" on a diameter. Where threaded parts are to be Sherardized they are undercut or overcut, as the case may be, to allow for this deposit. Complete tables of sizes are given in Tables I to IV.

In case of Sherardized parts containing holes and pieces fitting these holes, the allowance for Sherardizing is made in the hole, in other words, the hole is made .010" larger. This increase in deposit is equivalent to .85 to 1.1 oz. per square foot.

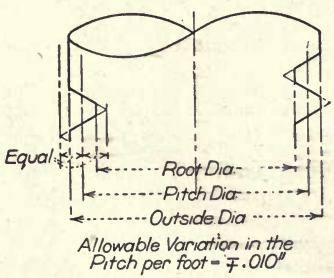

FIG. 131

In every case material Sherardized as per above will stand 170 hours as a minimum in a salt spray without showing discoloration due to corrosion of the iron, and may endure the spray even very much longer. This is considered the most satisfactory and rational test on Sherardizing. Some very interesting facts regarding the various tests are given in chapter XXXII.

Where body-bound bolts are used body of bolt should be made to size and allowance made in hole to allow for Sherardizing. Nuts to be Sherardized should be tapped .005" larger than standard.

TABLE I

BOLTS AND SCREWS (U. S. STD.)

Size	Outside Dia.			Pitch Dia.			Root Dia.		
	Min.	Max.	Dif.	Min.	Max.	Dif.	Min.	Max.	Dif.
¼" -20	.245	.250	.005	.2151	.2176	.0025	.1801	.1851	.005
5/16"-18	.3075	.3125	.005	.2740	.2765	.0025	.2353	.2403	.005
⅜" -16	.370	.375	.005	.3319	.3344	.0025	.2888	.2938	.005
7/16"-14	.4325	.4375	.005	.3886	.3911	.0025	.3397	.3447	.005
½" -13	.495	.500	.005	.4476	.4501	.0025	.3951	.4001	.005
9/16"-12	.5565	.5625	.006	.5054	.5084	.003	.4481	.4541	.006
⅝" -11	.619	.625	.006	.5630	.5660	.003	.5009	.5069	.006
¾" -10	.744	.750	.006	.6821	.6851	.003	.6141	.6201	.006
⅞" - 9	.869	.875	.006	.7999	.8029	.003	.7247	.7307	.006
1" - 8	.994	1.000	.006	.9158	.9188	.003	.8316	.8376	.006
1⅛" - 7	1.117	1.125	.008	1.0282	1.0322	.004	.9314	.9394	.008
1¼" - 7	1.242	1.250	.008	1.1532	1.1572	.004	1.0564	1.0644	.008
1⅜" - 6	1.367	1.375	.008	1.2628	1.2668	.004	1.1505	1.1585	.008
1½" - 6	1.492	1.500	.008	1.3878	1.3918	.004	1.2755	1.2835	.008
1⅝" - 5½	1.617	1.625	.008	1.5029	1.5069	.004	1.3808	1.3888	.008
1¾" - 5	1.742	1.750	.008	1.6161	1.6201	.004	1.4822	1.4902	.008
1⅞" - 5	1.867	1.875	.008	1.7411	1.7451	.004	1.6072	1.6152	.008
2" - 4½	1.992	2.000	.008	1.8517	1.8557	.004	1.7033	1.7113	.008

TABLE II—SHERARDIZED

BOLTS AND SCREWS

DIMENSIONS BEFORE SHERARDIZING

Size	Outside Dia.			Pitch Dia.			Root Dia.		
	Min.	Max.	Dif.	Min.	Max.	Dif.	Min.	Max.	Dif.
1/4" -20	.2400	.2450	.005	.2101	.2126	.0025	.1751	.1801	.005
5/16"-18	.3025	.3075	.005	.2690	.2715	.0025	.2303	.2353	.005
3/8" -16	.3650	.3700	.005	.3269	.3294	.0025	.2838	.2888	.005
7/16"-14	.4275	.4325	.005	.3836	.3861	.0025	.3347	.3397	.005
1/2" -13	.4900	.4950	.005	.4426	.4451	.0025	.3901	.3351	.005
9/16"-12	.5515	.5575	.006	.5004	.5034	.0030	.4431	.4491	.006
5/8" -11	.6140	.620	.006	.5580	.5610	.0030	.4959	.5019	.006
3/4" -10	.739	.745	.006	.6771	.6801	.0030	.6091	.6151	.006
7/8" - 9	.864	.870	.006	.7949	.7979	.0030	.7197	.7257	.006
1" - 8	.989	.995	.006	.9108	.9138	.0030	.8266	.8326	.006
1 1/8" - 7	1.112	1.120	.008	1.0232	1.0272	.0040	.9264	.9344	.008
1 1/4" - 7	1.237	1.245	.008	1.1482	1.1522	.0040	1.0514	1.0594	.008
1 3/8" - 6	1.362	1.370	.008	1.2578	1.2618	.0040	1.1455	1.1535	.008
1 1/2" - 6	1.487	1.495	.008	1.3828	1.3868	.0040	1.2705	1.2785	.008
1 5/8" - 5 1/2	1.612	1.620	.008	1.4979	1.5019	.0040	1.3758	1.3838	.008
1 3/4" - 5	1.737	1.745	.008	1.6111	1.6151	.0040	1.4772	1.4852	.008
1 7/8" - 5	1.862	1.870	.008	1.7361	1.7401	.0040	1.6022	1.6102	.008
2" - 4 1/2	1.987	1.995	.008	1.8467	1.8507	.0040	1.6983	1.7063	.008

TABLE III

MACHINE SCREWS (A.S.M.E. STD.)

Size	Outside Dia.			Pitch Dia.			Root Dia.		
	Min.	Max.	Diff.	Min.	Max.	Diff.	Min.	Max.	Diff.
0-80	.0572	.060	.0028	.0505	.0519	.0014	.0410	.0438	.0028
1-72	.0700	.073	.0030	.0625	.0640	.0015	.0520	.0550	.0030
2-64	.0828	.086	.0032	.0743	.0759	.0016	.0624	.0657	.0033
3-56	.0955	.099	.0035	.0857	.0874	.0017	.0721	.0758	.0037
4-48	.1082	.112	.0038	.0966	.0985	.0019	.0807	.0849	.0042
5-44	.1210	.125	.0040	.1082	.1102	.0020	.0910	.0955	.0045
6-40	.1338	.138	.0042	.1197	.1218	.0021	.1007	.1055	.0048
8-36	.1596	.164	.0044	.1438	.1460	.0022	.1227	.1279	.0052
10-30	.1852	.190	.0048	.1660	.1684	.0024	.1407	.1467	.0060
12-28	.2111	.216	.0049	.1904	.1928	.0024	.1633	.1696	.0063
14-24	.2368	.242	.0052	.2123	.2149	.0026	.1808	.1879	.0071

TABLE IV—SHERARDIZED

MACHINE SCREWS

DIMENSIONS BEFORE SHERARDIZING

Size	Outside Dia.			Pitch Dia.			Root Dia.		
	Min.	Max.	Diff.	Min.	Max.	Diff.	Min.	Max.	Diff.
6-40	.1288	.133	.0042	.1147	.1168	.0021	.0957	.1005	.0048
8-36	.1546	.159	.0044	.1388	.1410	.0022	.1177	.1229	.0052
10-30	.1802	.185	.0048	.1610	.1634	.0024	.1357	.1417	.0060
12-28	.2061	.211	.0049	.1854	.1878	.0024	.1583	.1646	.0063
14-24	.2318	.237	.0052	.2073	.2099	.0026	.1758	.1829	.0071

When the article Sherardized will be subjected to sharp bending or to considerable variations of temperature, the thickness of coating will be limited, for zinc, being more brittle and having a different coefficient of expansion than iron, will separate from the iron under these extreme conditions if too thick a coating is applied.

Temperature an Important Factor

As mentioned before, the effect of temperature is an important factor in both elements of the process, as the iron, with the increase of temperature, increases its power of absorption of zinc vapor and likewise the vapor tension of zinc increases with the temperature. According to authorities on vapor tension, with an increase of

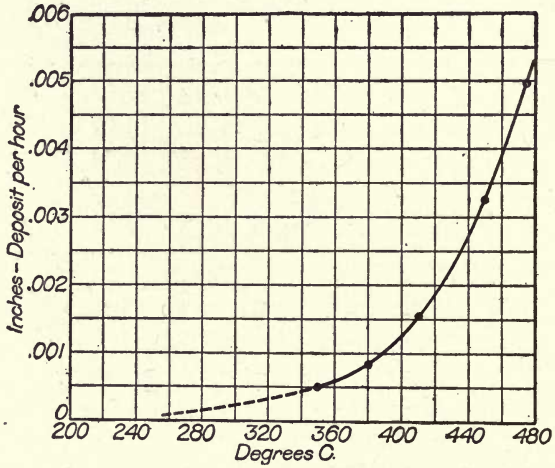

CHART I. RATE OF DEPOSIT AND TEMPERATURE IN ELECTRIC HEATED SHERARDIZING MACHINE

temperature from 325 to 375 deg. C., the relative vapor tension increases 14 times, and from 325 to 425 deg. C., the relative vapor tension increases 92 times. The absorption of zinc vapors by various metals (copper, nickel and iron) approaches the same rate at high temperatures up to about the melting point of zinc. Above this the absorption is exceedingly rapid.

From curves obtained by A. R. Johnson and W. R. Woolrich, it is seen that the greatest variation of absorption with a variation of temperature lies near the melting point of zinc, thus a fluctuation of lower temperature does not affect the absorption of the zinc

vapor to the same extent as at higher temperatures. In other words, more uniform absorption of zinc vapor is obtained at lower temperatures.

In view of the above facts it appears that when a metal is heated in the presence of the vapor of another metal, or the vapor of other elements or compounds, the metal evolves a portion of the gases or vapor which it contains, and in exchange accommodates the precipitation of the other vapors within its pores.

Operation of the Electric Heated Drum

The drum is started revolving at about ¾ to 1 r.p.m. and switch thrown to "high heat." The high heat is used to bring drum up to desired temperature (350 deg. to 375 deg. C.) to give correct

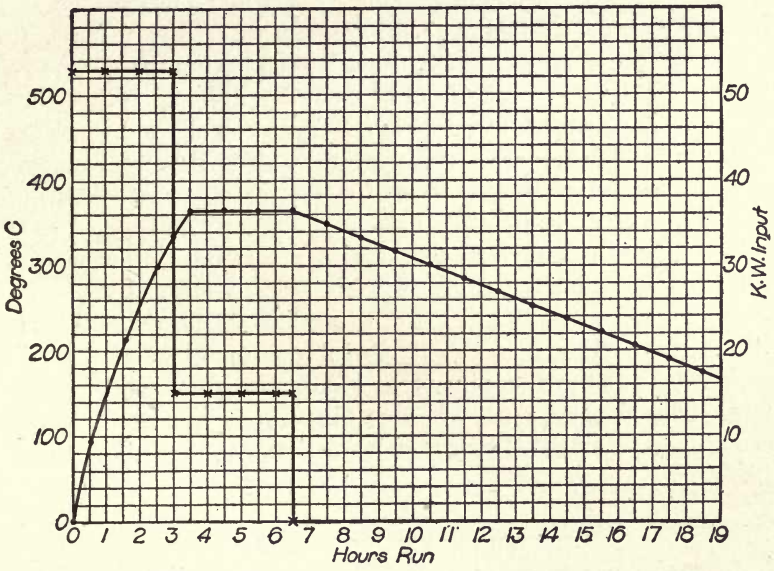

CHART II. TEMPERATURE AND POWER CURVE OF ELECTRIC-HEATED SHERARDIZING MACHINE 24" x 24" x 40"

deposit, and then the low heat is thrown on to hold it at that temperature for the required period (2½ to 3 hours) to give the deposit. After this current is thrown off and drum allowed to cool to 180 deg. C., which is a safe temperature to open drum. This should apply to Grasselli zinc only, as blue dust will fuse more

rapidly. Charts I and II provide interesting records of the power, temperature and deposit.

Sherardizing with Zinc Under Vacuum

After reading the above it is clear that to do Sherardizing we should have the zinc vapors at their greatest tension and have Sherardized iron in condition to give off the maximum gases. Zinc boils under ordinary pressure at 918 deg. C., and the boiling point under vacuum is reduced to 548 deg. C. Iron on being heated from 500 to 600 deg. C. in vacuum gives off gases readily. Therefore, it is quite clear that in vacuum the conditions are best for Sherardizing, and the writer was able to produce condensation of zinc on iron in a very short time. Some of the results were obtained under these conditions in minutes, where with ordinary pressure under the same conditions it required hours. This process and the machine for treating material by this method have been covered by patents.

The process is not necessarily dependent on having the substances supplying the vapor in the form of a powder, although a substance in this form may often be raised to a temperature above the melting point without fusing the articles together. The elevated temperature which can thus be secured is of material assistance in securing a rich vapor, which naturally hastens the process and therefore is an advantage in many cases. A further advantage of using the material supplying the vapor in the powdered form is the enormously increased surface which can thus be secured, thus giving a richer vapor, since the amount of material vaporized at a given temperature and pressure increases with increased evaporating surface. This is particularly of value when the boiling point of the vapor-giving material is above the temperature at which the deposition occurs.

Time an Important Factor

Just as temperature, so time is an important factor in the process of Sherardizing. Since articles of different size, shape and character are treated, if each were given its ideal condition of temperature and quality of zinc dust, the time of treatment of all would be alike, but this is not practical, for it is easier to vary the time of the process than the other factors.

It is possible to obtain almost instantaneous Sherardizing in the case of wire heated to a high temperature and allowed to pass

through zinc dust at normal temperature. In the case of many articles to be Sherardized this method is impractical and so longer periods of time are required. Not only the time of heating the article during the process should be considered but also the time of cooling, for this process is not confined to any one particular temperature, but takes place over a wide range of temperature. If the articles being treated have not become saturated during the heating period, the process will still continue upon cooling, until the temperature falls below its minimum point. There are two reasons for slowly cooling: First, to prevent loss from exposing hot zinc dust to the atmosphere (the metallic zinc particles would quickly oxidize); second, to prevent the articles being chilled too quickly.

Motion During Sherardizing

The general public has been given to understand that this is a tumbling process, and that the zinc will not deposit unless the drums are continuously rotating. If the articles are thoroughly mixed with the dust, it is not necessary to have the drums continuously rotating to insure uniform deposit, providing that the drums are not over 20 in. in diameter. An occasional turn of once in 15 minutes is ample to insure good results; too much rotating under heat pressure will make the articles appear dark and dusty.

Sherardizing can be and is being done where the articles to be treated are placed in the zinc dust, heat applied, but no motion given to either the dust or the articles during the process. This method is used in the case where large pieces, plates and sheets are being treated. If the transmission of heat through zinc dust were perfect and if the deterioration of the zinc particles were negligible, the motion of the articles during treatment would be unnecessary. Such, however, is not the case, for zinc dust is a poor conductor of heat and the deterioration of the zinc particles in intimate contact with the article treated requires a replacement of the same by new particles. Since this process continues during the cooling period, until it reaches its critical point, where it ceases, the motion will produce the same effect then as during the heating period.

Zinc dust, which is commonly called blue powder, is a flue dust and therefore a by-product of the zinc smelting furnace known as the Belgian furnace. It contains, as a rule, from 75 per cent. to 90 per cent. pure zinc. The supply is ample at a price a fraction above that of spelter, and it can be procured in any quantities that

may be required. The nature of the zinc, which is given off at a temperature of 1,000 deg. C. or more at the inception of distillation, comes into contact with the comparatively cold atmosphere of the flue and the sudden chill causes a rapid condensation of the vapor, so rapid, indeed, that it skips the liquid state and drops into the shape of perfectly spherical articles, of which about 30,000,000 can be crowded into a cube measuring 1/16″ in every direction. This impalpable powder, notwithstanding its high specific gravity, for it is only about 10 per cent. lighter than pure zinc, can be blown about like lycopodium. It is used very extensively by textile manufacturers for dye work, and by paint manufacturers, and is sold packed in barrels holding about 1,500 pounds. It cannot be melted into slabs on account of its rapid oxidation at a very low temperature. The peculiar properties of zinc dust have been ascribed by some to the presence of cadium which, being of more volatile metal, is distilled first from ore and then condensed into flues. One observer finds quantities ranging from 0.283 to 0.794 per cent. in flue dust after two hours of furnace operation. Others have claimed that these properties are due to the presence of zinc oxide or other impurities. Most of the zinc is purchased in Belgium or Silesia. Silesian zinc has been found the best adapted for Sherardizing, due to the fact that it has less moisture. A sample of an analysis showed the following:

Metallic zinc.....	88.95%	Cadium	0.62%
Zinc oxide.....	6.88%	Sulphur	0.055%
Lead	3.45%	Iron	0.04%

A fact that is undoubtedly responsible in a great measure for the mystery attaching to the action of zinc dust is its readiness to oxidize. It is only when oxidation is put out of its power, as in the closed Sherardizing drum, that heat will produce sufficient overstrain to cause the particle to burst into vaporized gas. This gas, so suddenly released, will condense instantly on the coolest spaces it can find. In Sherardizing, the coolest spaces are on the articles in the drum.

It is an established fact that in Sherardizing the presence of zinc oxide is necessary. We might suppose, therefore, that a molecule of oxide is reduced to voltaic action when it comes into contact with the iron. The zinc attaches itself to the iron, which acts, therefore, as a cathode in electrolysis, and the oxygen travels in the

opposite direction, combines with a free molecule of zinc to form a molecule of oxide, and goes through the same performance as before.

Zinc dust appears to break down into vapor at about 150 to 200 deg. C., although it undoubtedly begins to disintegrate at a lower heat. As the pressure increases it takes a greater amount of heat to cause the breakdown. As the vapor condenses the pressure is relieved and the hotter articles of dust are vaporized and re-establish an equilibrium.

Being a gas, the zinc vapor can force itself into the pores of the metal and form a deposit to a depth which will increase with the duration of the treatment.

Rapid cooling will cause the zinc to condense as crystals, the adherence of which to the iron is, however, inversely proportional to their size. Normal cooling would seem to yield in all cases a fine, glossy surface of what can be appropriately termed ferrozinc.

General Operation

There are three factors to contend with in the process of Sherardizing, viz., zinc dust, temperature, and the length of time the heat is run.

For example, take a standard size cylinder or drum 15″ to 20″ in diameter, ¼″ wall, new zinc dust at 90 per cent. metallic, temperature 750 deg. to 950 deg. F. outside of drum, with pyrometer stem showing at the bottom of the drums and protected from the flame by a baffle plate, the furnace started cold and allowing two hours to bring the temperature up to the required number of degrees and held at that point for three hours, should give good results. If, however, the deposit should not be sufficient, then the temperature should be slightly increased, say 25 deg. or the time of operation extended; but rules generally followed to compare with the ordinary ten hour per day time is to increase the temperature, which applies to ordinary material only. In cases where high tempered steel or spring stock is treated the time of operation should be extended and the temperature reduced to about 650 deg. F. for a 15″ drum and 700 deg. F. for a 20″ drum. The drums are then taken out and allowed to cool (under no circumstances should the drums be opened while hot, as the zinc dust will fuse and burn).

The time generally allowed for heats on ordinary material is

five and a half hours for the first heat, started from a cold furnace, and four and a half hours for the second heat, which allows one-half hour for making the change.

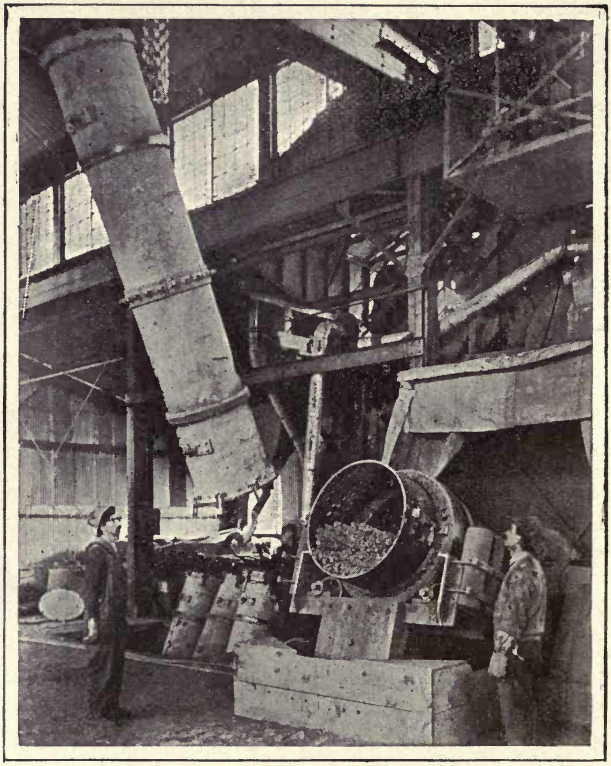

FIG. 132. UNLOADING INTO ROTARY DUST SEPARATOR

After loading, the drums are sealed and rolled into the Sherardizing furnace, as shown in Fig. 119 or 128. Here they remain for 5 to 6 hours, according to the tonnage that they contain, in an evenly maintained temperature of 780 deg. F.

Cooling and Unloading

Upon removal from the Sherardizing furnace the drums are rolled out on the cooling platform, as shown in Fig. 120 or 128, and allowed to cool out, as it is called, for 12 to 16 hours before

they are unsealed, as the introduction of oxygen to the zinc while in a superheated state would, of course, destroy it. The annealing incident to the slow heating and slower cooling through which articles pass in the process makes Sherardizing doubly valuable as a finish for steel products which, like electrical conduits, must be bent during installation, and for many cast-iron articles which would otherwise require a separate operation for the purpose.

After "cooling out" the contents of the drums are dumped into large hoppers, as shown in Fig. 132, and the surplus zinc dust rocked out, leaving, in addition to the zinc-iron alloy, an exterior coating of zinc.

CHAPTER XXIX

Don'ts in Sherardizing Practice

THE following account of the inspection and reorganization of a Sherardizing plant is included so the users of this book may profit by the experience of others and use the many valuable suggestions it contains in their own practice.

The plant was installed for the purpose of Sherardizing material for their own product. The material included bolts, nuts, malleable iron castings and line material. When the plant was installed the men in charge of the plant knew practically nothing about the process. Sherardizing was done in the same room with pickling and hot galvanizing. The steam and acid fumes from the large pickling tanks (used for pickling large castings preparatory to painting) not only had a deleterious effect upon the Sherardizing process, but also in connection with the zinc dust in the air, made working conditions almost intolerable. Whenever articles were pickled in large quantities they were first placed in an empty acid tank and the acid and water poured over them until covered. When, on inspection, the pickling process was completed, the acid was allowed to run into the sewer. Before all of these pickled articles could be washed off most of them had acquired a thin coating of rust which necessitated another dip in the acid before being Sherardized. No unloading pit had been provided, the dust being dumped upon the floor to be trampled under foot and, on several occasions, to be flooded by water. The ovens, too, were not suitable for the work. The clutches which connected the drums with the driving mechanism were crude and clumsy so that they could not be applied from outside. This necessitated cooling of the ovens to allow a workman to enter the oven to attach a clutch.

Considerable trouble had been encountered by the dust caking and balling in the drums. This became so bad at times that nearly a whole drum of work would be scrapped and much dust wasted. This condition was practically eliminated by confining the dust in a bin away from all water or acid vapors, as well as keeping the temperature within the limits for the particular dust used. The large pickling tanks and paint tank were removed from the build-

ing, giving more room, improving working conditions considerably and especially reducing the amount of acid fumes coming in contact with the zinc dust.

Eliminating Black Spots on Finished Work

One of the principal difficulties was the elimination of black spots on the finished work. At times this became very excessive, not only detracting from the appearance of the work but also reducing the number of dips the material would stand under test. Two principal causes were found for this fault. The first was the presence of "burnt in" slag in the corners or crevices of the material which it was almost impossible to remove by pickling in some instances. This was corrected by more intelligent inspection of the material, both before and after pickling. In connection with inspection, it was found that the material received practically no inspection before treatment. Whenever slaggy material reached the Sherardizing department, the inspector was notified and it was often found that the material had been removed from the foundry more than two years before. An entirely new system of inspection has since been adopted, which has taken care of the black spots from this cause.

The second cause was the presence of acid in the spongy or porous parts of a casting which was not thoroughly washed out or neutralized. It was difficult to obtain castings without some porous parts or corners that were filled with fine cracks, but by careful attention to pickling and neutralizing the black spots were reduced to a minimum.

Obviating Non-Uniformity of Coating

Another fault was the non-uniformity of coating even with the same kind of material in the same drum as shown by testing some of the material from different parts of the drum. A heat analysis of the furnaces showed a variation of temperature. This affected the uniformity of coating considerably, notwithstanding the drums were rotated through the run. This fault was corrected by putting new baffles in the furnace, additional heat insulation on the doors, and new burners, which gave more uniform distribution of heat. New clutches were also included in the general overhauling of the furnaces, which allowed the driving mechanism to be connected to the drums from outside the furnaces.

In order to save the excessive waste of acid eight small pickling tanks were installed, together with sufficient baskets for handling the material. An electric hoist was installed for handling the baskets of material from one tank to another. By this betterment the quality of pickling was improved as well as reducing the amount of supervision required because of systematizing the process. By handling the material in smaller quantities during pickling it was found that better inspection was possible.

Some difficulty was encountered in the case of one particular malleable iron article, or cap, which was swedged on the end of a wooden rod. In this case the Sherardizing must be done before the iron cap was formed on the rod. Whenever the Sherardizing was heavy this forming process would cause the cracking or peeling of the coating. By increasing the temperature and decreasing the time of the process (using blue dust) the quality of the coating was much improved. In this way the Sherardized articles would stand the same number of dips test with a much thinner coating and would retain their coating through the forming process.

Improving Psychological Condition of Men

In this connection the improvement in the psychological condition of the men cannot be overlooked. Under the adverse conditions the men, including those in charge, were very skeptical of the process. By explaining the process to them and investigating each part of the process with their co-operation it was found that much could be accomplished. This was done by improving the unbearable working conditions, as well as those having a direct bearing upon the process. Since these improvements were made this plant has been doing as good work as any others, while still further improvements would probably increase the convenience and lessen the cost of the process. This is an example of what has been done in one case to improve a plant and may be a means of helping others to overcome their difficulties, who have had the same or similar conditions to contend with.

It must be understood that zinc penetrating the metal is bound to bring to the surface all impurities and, while it does not interfere with the rust proofing qualities of the article, it makes it objectionable in appearance. The claim has been made that articles coming direct from the machine, covered with oil, can be Sherardized without cleaning. This is true where no fats are used with the

oil. In case of fats where the zinc will absorb it, it will redeposit these fats on the surface in the form of oxides, which has been mistaken in some instances for rust, as the appearances are very nearly alike. The two main fats used in oil for cutting down threads are bean oil and cotton seed oil. In case of clean oil, free from fats, with the zinc of sufficient strength to force its way through and absorb the oil, no special cleaning is required, but experimenting along these lines brings out the work dark. This also is an objectionable feature and therefore has not been found practicable when considering the small cost of cleaning.

Caution

Careful attention must be given to see that the dimensions of the bolts and nuts shall be such as to allow for enough clearance for the various kinds of zinc coating. These dimensions, where in normal cases the test is from 6 to 8 dips, should have an allowance for 8 to 9 mils.

Don'ts

DON'T deposit 6 or 8 pounds of zinc to make the article rust proof. Four pounds is sufficient, as too heavy a deposit will render the coating brittle and it will flake.

DON'T take it for granted that just because you have a nice, bright color it is rust proof. Test it and find out, as colors are very deceiving.

DON'T mix your floor sweepings in with your zinc. Save it and sell it, as the zinc dust in continuous contact with iron will gather dirt quickly enough.

DON'T leave sawdust and excelsior on the work to mix with the zinc as it will oxidize and darken the zinc and the material.

DON'T let your zinc dust stand around in open boxes or barrels as it will absorb moisture. Keep it in galvanized cans and covered.

DON'T throw water on zinc in case of fire as same will produce gas. Smother it with a blanket or sand.

DON'T get scared if you should look into the furnace and see fire around the cracks of your drums. It will stop as soon as the gas obtained from the moisture is burnt out.

DON'T open the drums until they are cold, or at least 150 deg. F.

DON'T expect Sherardizing to fill an uncalked seam. It is not a solder.

CHAPTER XXX

Coloring and Finishing Sherardized Articles

BY BUFFING the surface on a fine polishing wheel and afterwards placing it on a cloth wheel for color, a finish can be obtained which is more brilliant than nickel plating, comparing very favorably with silver plating, and which will not tarnish. The article Sherardized is a fraction darker and more velvety in appearance, due to the zinc coating, where nickel is a white coating. When cutting down for this finish the impression generally carried is that all the zinc is being ground off and relieved from the surface. This is not the case, due to zinc alloy, and if closely inspected a fine zinc coating will show, even through the most brilliant finish, and there is perfect rust protection, so long as this veining is visible to the naked eye. Further, the friction from a wheel caused in burnishing up the surface has a tendency to increase the crystal hardness of this coating so that it further resists weather action.

By taking a piece of cold rolled steel and Sherardizing it to a thickness of .001½", and passing it through the rolls cold and breaking it down twice its length, it will still show the same resistance against copper sulphate tests as before this reduction was made. This goes to prove that the more friction that is brought to bear, as previously stated, the more resistance against corrosion. It has also been found that material can be top finished in nickel, brass, copper and bronze, also can be readily japanned, enameled, and painted.

In the case of copper and bronze, after plating, the material should be set aside and let stand for forty-eight to seventy-two hours, for action between zinc and copper or bronze. This action makes the surface appear very dark but, after this action ceases, the work is then placed on a buffing wheel for coloring and no further action takes place. In the case of japanned coating it is recommended that the first dip be made in a solution of about 50 per cent. benzine and 50 per cent. japan. This thin coating insures a perfect body. This is baked on very hard and the second dip should be a heavier coating.

For lacquer finish no special operation is necessary, as it will deposit as readily as on the plain material. If a smooth surface is required simply buff the article on a cloth wheel or scratch brush before finishing.

This applies to large articles which cannot be tumbled. To obtain the smooth surface on small articles for plating or for other purposes, they are placed in a tumbling barrel. For dry tumbling use leather meal or leather chips, operation extending anywhere from two to ten hours. For wet tumbling use shot on light material only.

CHAPTER XXXI

Cost of Sherardizing Material per Ton with Different Fuels

A GAS burning furnace does not require the heavy reinforcement that an oil burning or a coke furnace requires because it is not under as much pressure. It has further been found that gas burning furnaces are easier to operate but more expensive. Fuel oil and coke are the cheapest known fuels in the East. Where natural gas is available, this by far is the cheapest fuel. The ordinary wear and tear on these furnaces is very small, due to the fact that less than 1000 deg. F. is required. It should be understood that as little structural iron should be used on the inner part of the furnace as possible, to keep from warping. A coke burning furnace requires about 3000 more brick than the ordinary oil and gas furnace, due to the fact that the fire box must be thoroughly reinforced for high pressure heating and retaining of heat, but with this equipment there are no extra installations such as producer gas machines and fuel oil machines necessitate.

Sherardizing is like annealing in that it requires a small amount of labor, and that unskilled labor, placed under proper supervision, can operate the plant as successfully as a high priced laborer.

Cost for Fuel Oil Burning

	Per ton
Fuel oil, one gallon per hour per burner, 3 burners per furnace, 30 gals. per day of 10 hours, at 5c per gal.....	$1.50
Zinc dust, average deposit 4 lbs. per 100 lbs. of material treated, 80 lbs. per ton, at $5.75 per 100 lbs., average market price	4.60
Labor, two men at 15c per hour, which includes the labor for cleaning, pickling, packing, etc.....	3.00
Total	$9.10

Producer Gas

	Per ton
Flynn & Dreffein's guarantee, cost averaged at the rate of 80 lbs. Pea Coal, equivalent to 1,000 feet of illuminating gas, at 75c per 1,000; consumption of furnace 4,000 ft. per day would be 320 lbs. of coal, at $4.50 per ton....	$0.72
Zinc dust, average deposit 4 lbs. per 100 lbs. of material treated, 80 lbs. per ton at $5.75 per 100 lbs.....	4.60
Labor, 2 men at 15c per hour, which includes labor for cleaning and pickling, per ton.....	3.00
Total	$8.32

Coke

	Per ton
Coke, 8 bu. per day at 10c per bu.....	$0.80
	Per ton
Zinc dust, average deposit 4 lbs. per 100 lbs. of material treated, 80 lbs. per ton, at $5.75 per 100 lbs.....	4.60
Labor, 2 men at 15c per hour, which includes labor for cleaning and pickling.....	3.00
Total	$8.40

Illuminating Gas

	Per ton
Gas, 4,000 ft. at 75c per 1,000.....	$3.00
Zinc dust, average deposit 4 lbs. per 100 lbs. of material treated, 80 lbs. per ton, at $5.75 per 100 lbs.....	4.60
Labor, 2 men at 15c per hour, which includes labor for cleaning and pickling.....	3.00
Total	$10.60

This being a patented process a royalty of $2.50 per ton must be added for the cost for every ton of material treated. With a large capacity plant the above cost would be less, due to saving both in fuel and labor.

Disposal of Used Zinc or Zinc Residue

When sufficient amount of zinc oxide has accumulated with the zinc to warrant disposal, discontinue the adding of new zinc, and

by extending the time of the operation or increasing the temperature, same will be reduced very rapidly until about 20 per cent. metallic, at which time it should be disposed of. There is always a market for this material, providing no sands, flint or other materials are mixed with the zinc for coloring purposes. This has been one of the objectionable features in the process, and very deceiving to the public in giving color and not zinc simply for appearance.

CHAPTER XXXII

Galvanizing Specifications and Tests

THE following specifications applied to the galvanized overhead construction material purchased by the Pennsylvania Railroad for the Philadelphia electrification, and all galvanized material used by the New York, New Haven & Hartford Railroad in their electrification improvements was required to meet these specifications before being accepted.

Specifications for Hot and Electro-Galvanizing

This specification shall apply to all galvanized iron or steel *except* that coated with zinc by the Sherardizing process.

Coating

The galvanizing shall consist of a continuous coating of pure zinc of uniform thickness, and so applied that it adheres firmly to the metal. The finished product shall be smooth.

Cleaning

The samples shall be cleaned before testing, first with carbona, benzine or turpentine, and cotton waste (not with a brush), and then thoroughly rinsed in clean water and wiped dry with clean cotton waste.

Solution for Testing Coating

The standard solution of copper sulphate to be used in testing shall consist of commercial copper sulphate crystals dissolved in cold water, about in the proportion of thirty-six parts, by weight, of crystals to 100 parts, by weight, of water. The solution shall be neutralized by the addition of an excess of chemically pure cupric oxide (CuO). The presence of an excess of cupric oxide will be shown by the sediment of this reagent at the bottom of the containing vessel.

The neutralized solution shall be filtered before using by passing through filter paper. The filtered solution shall have a specific gravity of 1.186 at 65 deg. Fahr. (reading the scale at the level of

the solution) at the beginning of each test. In case the filtered solution is high in specific gravity, clean water shall be added to reduce the specific gravity to 1.186 at 65 deg. Fahr. In case the filtered solution is low in specific gravity, filtered solution of a higher specific gravity shall be added to make the specific gravity 1.186 at 65 deg. Fahr.

As soon as the stronger solution is taken from the vessel containing the unfiltered neutralized stock solution, additional crystals and water must be added to the stock solution. An excess of cupric oxide shall always be kept in the unfiltered stock solution.

Quantity of Solution

Wire samples shall be tested in a glass jar of at least two inches (2 in.) inside diameter. The jar without the wire samples shall be filled with standard solution to a depth of at least four inches (4 in.). Hardware samples shall be tested in a glass or earthenware jar containing at least one-half (½) pint of standard solution for each hardware sample.

Solution shall not be used for more than one series of four immersions.

Samples

Not more than seven wires shall be simultaneously immersed, and not more than one sample of galvanized material other than wire shall be immersed in the specified quantity of solution.

The samples shall not be grouped or twisted together, but shall be well separated so as to permit the action of the solution to be uniform upon all immersed portions of the samples.

Tests

Clean and dry samples shall be immersed in the required quantity of standard solution in accordance with the following cycle of immersions.

The temperature of the solution shall be maintained between 62 and 68 deg. Fahr. at all times during the following test:

First. Immerse for one minute, wash and wipe dry.
Second. Immerse for one minute, wash and wipe dry.
Third. Immerse for one minute, wash and wipe dry.
Fourth. Immerse for one minute, wash and wipe dry.

After each immersion the samples shall be immediately washed

in clean water having a temperature between 62 and 68 deg. Fahr., and wiped dry with cotton waste.

In the case of No. 14 galvanized iron or steel wire, the time of the fourth immersion shall be reduced to one-half minute.

Results of Tests

After the tests described in "Tests" above, no bright metallic copper deposit shall show on the samples.

In case the article is threaded, the thread shall be clean and true after galvanizing and shall stand at least one immersion in the test solution. The rest of the article shall stand the specified four immersions.

The threads of nuts, except those galvanized by the electrolytic process, shall be cut after galvanizing, and the threads shall not be required to pass the tests.

Copper deposits on zinc, or within one inch of a cut end, shall not be considered causes for rejection.

In case of failure of only one wire in a group of seven wires immersed together, or if there is a reasonable doubt as to the copper deposit, two check tests shall be made on these seven wires and the lot reported in accordance with the majority of the sets of tests.

Failure to Meet Requirements

Any shipment or part of a shipment, the samples from which fail to pass the above requirements, may be rejected.

Testing Galvanized Products

Obviously the only final durability test of a zinc coating is the test of time while in use under actual conditions of exposure. This method however takes too long for commercial purposes and some other means of making comparative tests which will give prompt results must be adopted. Several such tests are in general use, and the following information taken from a booklet entitled "The History and Development of the Galvanizing Industry" and reprinted in *Metal Industry* covers the subject in an interesting manner:

The outward appearance of any galvanized article is not necessarily an indication of its excellence. This statement may be taken as a general rule applying to articles coated by either of the galvanizing processes mentioned herein.

For over forty years prior to 1880 the hot galvanizing process, which was practically the only galvanizing process in commercial use prior to that time, was believed to produce uniform results. It was, therefore, not deemed necessary to test such coatings by any other means than that of durability under actual weather conditions. Observations made by Sir W. H. Preece, chief of the British Post Office Telegraphs, led him to see the necessity of a test for zinc coatings on telegraph wires.

Preece, or Copper Sulphate Test

Between 1880 and 1890 Preece devised what is known as the "copper sulphate test" for galvanized articles, and this test has until recently been accepted as the final word regarding the quantity of any galvanized product. This test has been modified and standardized in the United States, notably by the chief engineer of the Western Union Telegraph Company, and has been quite generally adopted by producers and consumers of galvanized products, such as wire, sheets, line material, etc.

The original Preece test consisted in the immersion of the galvanized article in a saturated solution of copper sulphate for a period of one minute, removing, rinsing in water, wiping and again immersing in the copper sulphate solution. The number of immersions which the article could withstand before showing bright copper on the underlying steel or iron was taken as an indication of the excellence of the zinc coating.

Temperature Important

As at present standardized careful preparation of the copper sulphate solution is necessary. The solution is brought to a density of 1.186 specific gravity at a temperature of 65 degs. Fahr. This solution is usually treated with a small portion of cupric oxide to neutralize any free acid which might exist in the copper sulphate crystals. Galvanized articles are first to be cleaned of dirt and grease by immersion in gasoline or benzine, then rinsed in water and wiped dry.

After this preparatory treatment the articles are given successive one-minute immersions in the standard copper sulphate liquor, held at a temperature of from 65 to 70 degs. Fahr., rinsed thoroughly in water and wiped dry after each immersion. The samples are to be carefully scrutinized after each immersion, and if spots

of a clear copper color are observed, the coating is said to have failed. The number of successive immersions which the article will withstand without showing indications of clear copper is taken as an indication of the quality of the coating. A new portion of solution is to be taken for testing each article.

Limitations of Copper Sulphate Test

It will be noted that the Preece, or copper sulphate test, determines only the thickness of the zinc coating at its thinnest portion. It is, therefore, not in any sense a determination of how much or how little zinc is deposited on the article under test. It is well known that the copper sulphate test is unsuitable for testing Sherardized articles, and it is a fact, however not generally known, that the copper sulphate does not attack zinc coatings deposited electrically, and by hot galvanizing methods at equal rates. It has been further demonstrated that the different temperatures of the molten bath and different methods of cooling articles galvanized in molten zinc show entirely unreliable results when subjected to the copper sulphate test. From these remarks it will be seen that it is unfair to test competitively zinc coatings applied by Sherardizing, hot galvanizing and electro-galvanizing methods.

Lead Acetate Test

Owing to the unsatisfactory results secured by means of the copper sulphate test, in a measure pointed out in the preceding paragraphs, an accurate quantitative test for galvanized products has been devised. The lead acetate test, as it is known, was recently originated by Prof. W. H. Walker, of the Massachusetts Institute of Technology, Boston.

The test is designed to show the weight of actual coating covering products galvanized by any of the well-known methods. It takes into consideration the impurities residing in the coating and the main impurity usually found, i. e., iron, may be determined if desired. In practice, however, it is seldom carried out to this extent. The solution employed removes from the articles both the zinc and zinc-iron alloys present. The accurate weight before and after testing furnishes the basis for computing the quantitative value of the coating. It is unnecessary to take the time of sample immersion accurately, in which respect the lead acetate test differs

from the copper sulphate test; however, the weighings, which must be accurate to one milligram, require considerable time and care. The lead acetate solution is prepared as follows:

Dissolve 3 pounds of commercial lead acetate crystals ($Pb\ (C_2H_3O_2)2+3H_2O$) in one gallon of distilled water and add 1 oz. litharge (PbO). After complete solution of the lead acetate, the mixture should be stirred vigorously and any undissolved residue allowed to settle. The clear liquor is then poured off and the solution is ready for use. It is unnecessary to maintain any accurate temperature of solution as is required in the copper sulphate test, and the solution may be used for several tests without renewal, until such time as the action becomes too slow.

Samples of galvanized product are first to be thoroughly cleaned of oil and dirt by rinsing in benzine or in gasoline, then rinsing in cold water and dried with clean cotton waste. The sample should next be weighed to an accuracy of one milligram, and the weight noted. The sample is then ready for immersion in the lead acetate solution.

The length of time during which the sample is under treatment is usually about three minutes, although it may be left in for a longer period without affecting the result. These immersions should be repeated until all of the coating has been removed and the sample exhibits the clean steel underneath. A short experience will enable the operator to tell with certainty when all of the coating has been removed. After each immersion in the lead acetate solution, the flocculent or loose coating of spongy lead which is deposited must be carefully removed; for this purpose it is usual to employ a small, soft bristle brush, care being taken that no lead is "burnished" over the zinc coating. If any spots of lead are noted, which the solution does not remove, the careful use of a sharp knife is necessary. When the coating is all removed, the sample is then dried by immersion in alcohol and ignition, or by placing over a small steam coil. Final weight of the sample is then taken and noted.

If it is desired to estimate the amount of iron in the coating, the samples must be rinsed in clean water contained in a beaker, care being taken that all lead acetate and solution washings are saved. The lead acetate and the wash solutions may be put together and filtered, and slightly acidified with sulphuric acid; a few particles of granulated zinc should then be added, when the

amount of iron is ascertained by titrating the solution with a standard solution of potassium-permanganate. The lead may be balled and squeezed with the fingers, and saved if desired.

The lead may be weighed and the amount of zinc coating removed may be calculated from the weight of the lead, the preferable manner of determining the amount of coating on the sample under test is as follows: Deduct the final weight of sample after treatment in the lead acetate solution from the original weight of the galvanized piece. Divide the net weight of coating so obtained by the weight of the bare or uncoated sample, whence the per cent. of loss in weight is ascertained nearly enough for all practical purposes. Apply the per cent. loss figure to 2,000 lbs. representing a ton of the articles in question. This will give the pounds of coating per ton of product.

Next, ascertain by close measurement or estimation how many sq. ft. of surface there are in a ton of 2,000 lbs. of the articles under examination, reducing the lbs. coating per ton found by the application of the percentage figure, to ounces by multiplying by 16. Having the ounces of coating per ton and the number of sq. ft. of surface per ton, divide the former figure by the latter, and find the ounces per sq. ft.; this is usually a decimal figure. The ounces of coating per sq. ft. gives a unit which may be used for the purpose of comparing the values of coating on different styles and kinds of galvanized product.

Samples of galvanized articles which are to be given the lead acetate test must be above all things smoothly galvanized, without adhering lumps or drops of spelter, since these imperfections would lead to erroneous conclusions by adding to the net weight of coating particles of metal not evenly distributed, wherefore the resultant ounces per sq. ft. would be too high; it should be carefully observed that all portions of the galvanized article are coated, unless the uncoated areas are left out of the area figure per ton.

Caustic Soda Test

Prof. Walker has rendered further service to those interested in testing galvanized materials by supplying a test which will show the presence or absence of pores or cracks in zinc coatings.

A strong solution of caustic soda in water is heated to a temperature of about 210 degs. Fahr., and the galvanized article suspended in this solution by a string or other non-metallic suspension. If

pin holes or cracks exist in the coating, bubbles or hydrogen will be observed to come from the surface of the article at these points, while if there are no pores or cracks in the coating, no action will be observed. The caustic soda test will show whether or not the coating has cracked when the galvanized article is bent after galvanizing.

In a recent issue of *The Iron Age* Mr. Samuel Trood has also given special consideration to the use of the various texts from the standpoint of an expert on Sherardizing.

The Preece Test

The solution is made up by dissolving 36 parts by weight of commercial copper sulphate crystals in 100 parts of water and then neutralizing by the addition of excess of chemically pure cupric oxide. The presence of excess oxide is indicated by the undissolved part settling to the bottom of the vessel.

It is difficult and takes much time to get the copper sulphate into solution at room temperature, even if the solution is agitated by blowing air through it, or if the crystals are suspended in a basket near the top of the solution. Heating will greatly accelerate the rate of solution, and in this way a solution can be prepared a little stronger than that desired, the final exact adjustment being afterward made by diluting with water. To do this accurately and rapidly, add a certain number of cubic centimeters of water to about 5 liters of solution, and note how many thousandths change this produces in the specific gravity. One or two further additions will then suffice to get an accurate adjustment of the strength.

It was noted that, after the finished solution has been filtered off from the copper oxide, CuO, in the bottom of the stock bottle, there is separated out, sometimes a reddish or sometimes a bulky pale green precipitate, after the solution has stood for a considerable time, due to some impurity, or it may be to some basic salt of copper. It probably does not affect the strength or neutrality of the solution appreciably, since the quantity is not great. However, for very accurate work it might be desirable to determine the effect of this change, and whether it is desirable to always use a solution recently filtered off from CuO sediment.

The descriptions of the test specify that the strength of the solution shall be 1.186 at 65 deg. Fahr. It would be desirable to know the permissible variation from this, that is, the error due to having

the strength 1.184 or 1.188, for example; further, it would simplify the operation of making up the solution, if only an occasional one is made up and means for getting the temperature exactly adjusted are not convenient, to know what specific gravity to aim for if the temperature is 70 deg. or 80 deg. Fahr. After the strength has once been adjusted, the temperature at which the solution is used has an effect upon the accuracy of the test. This will be taken up in another paragraph.

Manipulation of the Test

There does not seem to be published information on the one point that determines whether or not the operator will have success when he attempts to apply the Preece test to Sherardized and alloy-coated articles. This is that the specimen must be brushed instead of wiped, in removing the loose copper after each dip.

The copper which replaces the zinc on a galvanized coating is in such a loose non-adherent form that it can be easily wiped off with cotton waste, but that which forms on Sherardized coatings is more adherent, probably due to the slower rate at which zinc-iron alloy precipitates copper from the solution as compared with zinc itself. Further, the Sherardized surface is rough so that, if the specimen is wiped with waste, the copper, instead of being removed, is rubbed into the hollows of the surface. This copper then protects the still remaining underlying alloy from further action of the solution and the test is spoiled. The further solution of the protected alloy is retarded so that, if the dips are continued, the specimen will appear to stand more dips than correspond to the thickness of coating present or even may stand an indefinite number of dips. On the other hand, if the operator has not had some experience, he may interpret this premature appearance of copper as a failure, since after several burnishings by waste, the copper on alloy may take a polish that resembles closely the appearance of copper formed on the iron. By removing the copper after each dip by vigorous brushing with plenty of water, as under a faucet, the risk of rubbing it into the hollows is practically eliminated.

In a Sherardized specimen the portion of the coating next to the iron shows a lighter color during the Preece test than that nearer the surface. For this reason, then, after brushing and drying, a light patch shows up on a darker background, it indicates that the coating is thin at that point and failure is to be expected.

Sometimes, due to imperfect brushing, copper will form on the surface of the coating, as mentioned, but this copper can be distinguished from the copper formed on the iron at the point of failure in several ways. The copper at the failure is lighter in color than that due to improper brushing, it is surrounded by an area of light colored coating and it forms in the hollows or "valleys" of the coating, while the other forms on the higher portions or "hill tops." This last difference is always noticeable under a magnifying glass, but it can be distinguished by the eye after a little practice.

The regular Preece test was made on some No. 16 gauge wire which had been given a Sherardized coat in such a manner that it was very smooth. It was noticed that the copper which formed could be wiped off with waste and that the test would give the same results whether the wiping was done by waste or by brush. In order to determine whether the character of the coat affected this, similar tests were made on Sherardized sheet. One sheet had a rough coat while the other was smooth. Both were dipped at the same time in the same solution and both were wiped with waste. After the fourth dip the copper which had deposited on the rough specimen was rubbed into the crevices of the surface and gave a copperish color to the specimen. Large patches of this copper were burnished to a metallic polish. The copper which had deposited on the smooth piece showed practically no tendency to remain, as there were few cracks or hollows in which it could form.

A specimen of Sherardized sheet 2½x4 in., with a very thick Sherardized coating, was dipped into a solution 2 inches. One-half of the tested part was brushed after each dip and the other half was wiped with waste. After the third dip fine copper began to collect on the wiped half in the crevices of the coat and the amount increased after each dip. The brushed side kept a uniform dark color through the entire test showing no deposition of copper. The copper formed on the wiped half became thicker after each dip. The Sherardized coating where it was not protected by this layer of copper became thinner and eventually failed. The appearance of the coating on the brushed half was uniform and showed no indication of failure. The elevated deposit of copper on the wiped half could be flaked off. The premature failure of the wiped half was due to the accelerating action of the heavy elevated deposit of copper; that is to say, the burnished copper on the alloy protects

only the alloy directly beneath it, but accelerates the solution of immediately adjoining areas of alloy. The elevated copper had a nodular rough surface while that deposited on the iron at the failure was smooth and bright.

Temperature of the Solution

The American Steel & Wire Company specifies that in carrying out the dip test the temperature of the solution must be between 65 and 70 deg. Fahr., while the American Telephone & Telegraph Company specifies 62 to 68 deg. Fahr. It is of interest to know the percentage of error due to temperature variations, especially when only an occasional test has to be made, since it may then take much more time to arrange to get the right temperature than to run the tests. Results obtained with solution at different temperatures, 75 c.c. of solution being used, are:

Temperature	Average loss, gr. per sq. in.
55 deg. F.	0.0291
65 deg. F.	0.03185
75 deg. F.	0.0345
85 deg. F.	0.0397

These figures show that if a specimen is very close to the point of rejection a difference of 10 degrees may easily mean rejection or acceptance for the same actual thickness of coating.

Consideration of Objections to Preece Test

The accuracy of the Preece test has been called into question by Patrick and Walker (Journal of Industrial and Engineering Chemistry, April, 1911), for the reason that the rate at which $CuSO_4$ solution dissolves zinc is different from the rate of solution for zinc-iron alloy. The rate of solution is slower for the zinc-iron alloy because of its lower potential as compared with zinc. But this lower potential would seem to indicate a correspondingly slower corrosion by atmospheric influence, so that the number of dips in a corrosive solution that a specimen will stand is a fairer indication of its resistance to corrosion, and therefore the usefulness of the coating, than the actual weight of the zinc present. It is a determined fact that less weight of zinc in the form of Sherardized coat will afford protection equal to a greater amount of zinc in the form of a hot or electrogalvanized coating.

Determinations have been made of the relative rate of solution

of several kinds of coating in the standard $CuSO_4$ solution with the following results:

Specimen	Loss, gr. per sq. in. per dip
Hot galvanized wire	0.0135
Alloy coated nail (Sherardized)	0.0082
Sherarduct	0.0109
Galvaduct	0.0131

It is evident that the Sherardized coat dissolves materially more slowly.

In comparing one specimen of hot galvanized material with another, there may be a slight discrepancy in the relation between the number of dips and the actual weight of coating. This is due to the fact that in different specimens of hot galvanizing the ratio between alloy and pure zinc present may vary from something like 1 of alloy to 4 of zinc, to 1 of alloy to 10 of zinc. Again, it may be fairly assumed that the important thing to know is the number of dips the specimen will stand rather than the weight of material present. If, however, some buyer or manufacturer should consider weight the only factor of importance, it is evident that a difference of rate, as indicated in the above table, is not so serious when it is borne in mind that it affects only ¼ to 1/10 of the coating; further, when the Preece test is used as a regular commercial control by some buyer or manufacturer, the articles compared from day to day are probably usually so made that the variation in the proportion of alloy present is not a maximum one.

In the same article, Patrick and Walker assert that the end point is unreliable. As far as Sherardized articles are concerned, practically all of this uncertainty as to the end point arises from the fact that the specimen is not brushed properly. The importance of this has been discussed under "Manipulation of the Test." It is true, however, that it takes more practice and more careful discrimination to use the Preece test for Sherardized articles than for hot or electrogalvanized objects.

In order to get additional proof that really adherent copper deposits only upon iron and not upon alloy, specimens were prepared and examined under the microscope. It was noted that the only bright copper on the brushed specimen was on the iron, while the thin alloy surrounding the place of failure showed none whatever. Before brushing there was copper on this alloy.

Sellers of hot galvanized ware have raised objection to permitting

the brushing of samples of Sherardized ware, in carrying out the Preece test. As long as there is any coating left the brushing can certainly do nothing that would make the Sherardized article show up better than it should; if anything it would remove some of the coating and hasten the failure, to which the sellers of galvanized ware would certainly not object.

The only possible contentions of the hot galvanized ware sellers would then be that the brushing might remove copper that is deposited upon iron. According to observations made on this point, only the most violent brushing will do this and there is not the slightest difficulty in avoiding it. The use of the stiffest brush that could be bought in a local drug store did not bring about the removal of this copper, and a much softer brush is perfectly sufficient to give the samples all the brushing they need, if only a burnishing effect is avoided.

Probably the only way in which there is danger of removing copper from iron is a bending back and forth or other considerable distortion of the specimen; or, after the coating has been removed and the next dip would deposit copper and iron, to get the specimen dirty or greasy by using a greasy or soapy brush or handling with the hands. If the sample is laid upon a board, in brushing, as may be desirable with light flexible objects, in order not to scale off any copper, the board should of course be free from soap, grease, dirt or chemicals.

The Lead Acetate Test

In preparing the solution used, difficulty was found in getting the prepared quantity of lead acetate into solution. It is true that by heating this solution would be indicated. One difficulty encountered in working the test was due to the deposition of adherent lead on Sherardized samples immediately on immersing, particularly those coated by dust. This adherent lead cannot be wiped off and protects the underlying coating from going into solution. The area of adherent lead on some specimens was over 90 per cent. of the total surface.

Before the remedy for obviating the formation of adherent lead had been found, it was attempted to determine the loss of weight per dip. Instead of a loss, a gain in weight was found, showing conclusively that adherent lead was formed. Test pieces consisting of Sherardized nails with the points cut off were used. These were

immersed each time to constant depth. The area of the surface exposed was therefore constant in each dip. The nails were cleaned in gasoline, washed and dried; one-minute dips; brushed lightly and dried after each dip.

During dip No.	Nail No. 1, gain in grams	Nail No. 2, gain in grams
1	0.0011	0.0014
2	0.0024	0.0020
3	0.0028	0.0014
4	0.0010	0.0003

A similar nail was dipped into the solution and only adherent lead formed. The nail was removed and a knife blade scraped lightly across the surface and replaced. Loose, black crystalline lead immediately formed on the scratched portion, while none formed on the other parts of the nail.

Two nails similar to those previously mentioned were dipped in the same manner after they had been brushed with a dry brush and wiped with a dry towel. The deposition of loose lead in this case took place in spots, but covering the lesser part of the surface. These spots grew slowly during the dip. The brushing after each dip was done lightly.

During dip No.	Nail No. 1, loss in grams	Nail No. 2, loss in grams
1	0.0008	0.0036
2	0.0018	0.0029
3	0.0017	0.0051

As will be seen from the next determination, these are not normal results. Several other devices were tried to bring about the proper action of the solution. The specimens were thoroughly moistened, a hot solution was tried, the specimens were moved around in the solution, but no results were obtained.

In the next test the sample was treated before dipping with about 20 per cent. acetic acid for about 20 seconds, or until a distinct evolution of gas took place over its entire surface. After washing and drying it was dipped and weighed as in the previous test. The deposition of loose lead took place over the entire surface immediately after immersion.

During dip No.	Nail No. 3, Loss in grams	Nail No. 3, Loss grams per sq. in.
1	0.0201	0.0199
2	0.0163	0.0161
3	0.0138	0.0137
4	0.0141	0.0140

A similar test with a larger nail, dipped in acetic acid before putting into the lead acetate solution, gave the following results:

	Nail No. 4	
During dip No.	Loss in grams	Loss grams per sq. in.
1	0.0120	0.0235
2	0.0084	0.0165
3	0.0085	0.0167
4	0.0092	0.0180
5	0.0089	0.0174
6	0.0086	0.0169

Instead of dilute acetic acid, very dilute hydrochloric acid can also be used, about 10 per cent., and the specimen immersed in this about 10 seconds. It is probable that the reason that the lead acetate solution does not act properly at the start is that there is some zinc or iron oxide on the surface of the object.

Patrick and Walker do not approve of a "dip" method of testing the thickness of a coating, no matter what solution is used, but believe that the weight of the coating should be determined, either by weighing the lead deposit or by noting the loss of weight of the specimen. Either of these methods takes more time than that of counting dips, and the method of collecting, drying and weighing the lead seems especially cumbersome for a routine works test. The calculation of the results will take time also, unless there are a great number of samples of the same shape and size to be tested.

Preece and Acetate Methods Compared

1. For commercial testing the Preece method can be satisfactorily used for Sherardized as well as for hot dip and electrogalvanized articles, if the specimens are brushed properly. It takes more practice to detect the end point for testing Sherardized goods.

2. When used as a dip method the lead acetate test has the advantage of showing the end point with less practice on the part of the operator. It is troublesome for Sherardized articles since the samples must be dipped in acid, as described, in order that the test can be worked.

3. The lead acetate solution removes about 1.6 times as much coating per dip as the copper sulphate solution. It would be desirable, in order to prevent confusion, to adjust the solution, if possible, so that a dip removes the same quantity in both cases. If a weaker solution is used in order to reduce the rate of solution

for the lead acetate solution there may be more trouble with the formation of adherent lead.

4. As a testing method for scientific investigations to determine the exact weight of coating the lead acetate determination has the advantage that it removes the coating without depositing anything on the iron, resulting in an accurate determination. However the error due to the small amount of copper replacing iron cannot be material if it is desired to use the copper sulphate solution in order to determine the loss of weight of the specimen.

5. The lead acetate method affords a means of determining the percentage of iron in the coating. This is not essential for routine factory testing, and in fact the iron determination would be too troublesome for regular works control.

6. If it does not seem possible or desirable to overcome the objections of the sellers of hot galvanized ware to brushing Sherardized samples during the Preece test, the lead acetate method may be a useful substitute or at any rate a good check method to show that brushing does not result in too favorable indications for Sherardized goods when tested by the Preece method.

7. It does not seem justifiable to concur in Patrick and Walker's recommendation to substitute a weighing method for the dip method for commercial purposes, or to substitute the lead acetate dip method for the copper sulphate method.

Electrolytic Methods

Some experimental work was carried on which showed that by removing a Sherardized coating by electrolysis in a solution of potassium nitrate the ampere-minutes of current passed would indicate the weight of the coating. At this time the tests were all carried to the point of total removal of the coating.

If this method were modified, so that a constant amperage were used, and the specimen removed from the solution from time to time, say every half minute, and the test stopped when failure was first noted, the thickness of coating would be indicated by ampere minutes, which in this case could be readily noted since the amperage has been kept constant. In order to insure a uniform rate of solution for all parts of the sample, all parts of the specimen should be equally distant from the cathode. If the shape of the object prevents this, the distance should be made great enough, by using a large vessel, so as to make the variations insignificant.

Care must be taken to use a voltage lower than the decomposition voltage of water.

As regards the Sherardized coating, the disadvantage of this method would be that the same or greater weight of coating would go into solution per ampere minute as for hot galvanized. As pointed out, this is not the case with the Preece test. However, the test might at times be useful for a laboratory test for the use of the Northern Chemical Engineering Laboratories, or as a check method, without making any effort to bring about its general adoption as a commercial control method.

Caustic Soda Test

Another test for a zinc coating is the caustic soda test as supplied by Professor Walker. This test will show the presence or absence of pores or cracks in zinc coatings. The galvanized article is suspended by a string or other non-metallic suspension in a strong solution of caustic soda in water, heated to a temperature of 210 dgs. Fahr. If pin holes or cracks exist in the surface, bubbles of hydrogen will be observed to come from the surface of the article at these points, while if no pores exist no hydrogen will be evolved.

After considering all the possible methods of testing protective coatings, which is the best method for testing Sherardized material? The best one is that which can be successfully used on a commercial scale by a $12 a week apprentice.

Government Galvanizing Test

In using this test, take distilled water and sulphate of copper, C.P., sufficient to make a saturated solution leaving some sulphate undissolved. Solutions to be used at a temperature of 60 deg. Fahr. Test calls for one minute immersion of galvanized work, after which the work is rinsed in cold water and dried, and again immersed in a new testing solution for one minute and again washed and dried out and so on until the requisite number of one-minute dips have been made. When the zinc coating breaks down and shows a deposit of bright coppery red the test is finished. A slight appearance of copper does not necessarily mean that the zinc coating is entirely broken down, but, a bright red deposit must show. For some characters of work two one-minute tests are required without the galvanized coating breaking down, in others four are required.

Professor Burgess, of the University of Wisconsin, who has com-

piled very interesting data, some of which has been quoted, has found that this test is not always suitable for judging the thickness and quality of electro-zincing. For testing the power of resistance of the coating Professor Burgess has made use of diluted sulphuric acid and has found that an electrically deposited coating one-third the weight of that produced by the hot galvanizing processes has the same power of resistance to corrosion as the latter and that for a coating of equal thickness the proportion of resisting power is as 10 : 1.

A table showing the time of deposit, current used in number of amperes and the resistance to successive one-minute immersions as indicated in government test is appended.

Amperes used per sq. ft. surface	1st test ⅛ oz. per sq. ft. Minutes	2nd test ⅓ oz. per sq. ft. Minutes	2rd test ½ oz. per sq. ft. Minutes	4th test ⅔ oz. per sq. ft. Minutes
100	2⅝	5	7⅝	10
90	2¾	5½	8	11
80	3	6	9	12
70	3¾	7	10½	14
60	4	8	12	16
50	5	10	15	20
45	5½	11	16½	22
40	6	12½	19	25
35	7	14	21	28
30	8	16½	25	33
25	10	20	30	40
20	12½	25	37½	50
15	16½	33	50	66
10	25	50	75	100

Salt Spray Test for Sherardizing

Another test which is claimed to be particularly well adapted to making comparisons of the durability of metallic coatings applied by processes of different character is described in a paper read by Mr. J. A. Capp, of the General Electric Company, at the seventeenth annual meeting of the American Society for Testing Materials.

There are several processes commercially used for covering the surfaces of metals easily corroded or rusted, such as iron in its several forms, with other metals less easily corroded, or with metallic oxides. These may well be called "metallic" protective coatings in distinction from the types of coating which are in the nature of paints or their equivalent.

The object of the application of these metallic protective coatings

is to enable the coated articles to resist atmospheric exposure without rusting for a longer time than they could withstand such exposure without protection. Obviously, then, the only final test of the efficiency of a given type of coating is actual exposure to the same sort of influences that the material is supposed to resist in service. If the coating is at all efficient, this takes so long a time that more rapid methods of determining relative efficiencies become a necessity. The most commonly used methods of testing such metallic protective coatings are those of chemical attack, which in effect measure either the thickness or the weight per square unit of the protective coating. Such methods of chemical attack permit the comparison of results obtained from tests upon the same sort of coating, but difficulty is encountered when attempt is made to compare the results obtained by such tests on one sort of coating with those obtained on another character of coating. For instance, the well-known Preece test yields excellent comparative results on galvanized coatings. When, however, it is used for coatings applied by the Sherardizing process, the results are not at all comparable. Neither is the Preece test applicable to coatings of tin or of lead. In the case of Sherardized articles, it has been suggested that the coat, which is a combined structure of zinc and zinc oxide, together with some zinc-iron alloy, be removed in strong alkalies which will not attack the iron beneath. This would enable one to determine the weight of coating per unit of surface calculated to metallic zinc, but experience has shown that the results do not necessarily indicate the efficiency of the coat, and that it is not easy to determine the relative proportions of zinc and zinc oxide. Furthermore, comparison of the efficiency of a Sherardized coating with ordinary galvanizing is not possible when the Sherardized coating is tested by solution in a caustic alkali, while the galvanized coating is subjected to the Preece test.

Some years ago, when testing electrical insulation such as is used for overhead line construction, we found that material which stood fairly well when immersed in water failed badly when exposed to the weather, especially if exposed during a hard rain. This led us to produce a rain in the laboratory by sending a stream of water through an ordinary rosette such as is used with a gardener's watering can. The results were encouraging, but too severe, because the individual streams played steadily on one spot and produced erosion. Then we tried an atomizing nozzle, projecting

a cloud of moisture into a chamber in which the test specimens were exposed; the results were better, but there was still a possibility of some wear if the article was directly in the path of the stream and near to the nozzle. The problem seemed to be solved when care was taken in placing the articles to keep them out of the direct path of the jet issuing from the atomizing nozzle. As experience was gained with this type of test, as applied to insulating material, it was found that what seemed to be the essential requirement was the maintaining of an atmosphere substantially saturated with moisture; and this saturated-atmosphere exposure has been one of the tests regularly applied to all insulating materials intended for outdoor use since it was first worked out some fifteen years ago. It has been found to give reliable indications of the ability of insulation to resist weather, except, of course, as such ability is affected by extremes of heat and cold, erosion from the wind carrying dust particles, etc.

The problem of determining the resistance of protective coatings to weather corrosion is very similar to that of testing insulations for their weathering qualities. The conditions of exposure are the same, and hence there seemed to be no essential reason why the saturated-atmosphere test would not apply equally well to protective coatings as to insulation. Tests were begun several years ago to try out the method, and the only fault found with it was that it was somewhat slow. Good coatings did not show any signs of breaking down after several weeks of continuous exposure to the fog; yet there was encouragement in the fact that bare metal began rusting in a few hours, and rust spots began developing on poorly protected surfaces in from a few days to a week.

The fact that more trouble is experienced with trolley-line suspensions along the seashore than with the same devices inland, led immediately to the trial of an atmosphere saturated with salt water, with astonishingly satisfactory results.

As now used, the test consists in exposing the Sherardized articles in a copper-lined box, such as is illustrated in Figs. 133 and 134, into which there is projected by compressed air an atomized spray of $2\frac{1}{2}$ per cent. solution of NaCl in water. Care is taken to avoid placing the test specimens directly in the path of the jet. To insure constant saturation, an excess of salt is kept in the water at the bottom of the chamber. The spray is produced by a jet of compressed air lifting the water to the nozzle, whence it is pro-

jected as a cloud. This apparatus is of the common atomizer type. The chamber is necessarily not tightly sealed, but is open sufficiently to permit "breathing"; when used with an air jet, there is a slight pressure which is relieved through the breathing openings. If desired, the test may be modified by the use of a fine steam jet to raise the temperature of the atmosphere in the chamber. The specific gravity of the water is kept at 1.026 and 1.03 at 60 deg. F. There is also the possibility of rendering the test atmosphere slightly acid or alkaline by suitable additions to the water in substitution for the salt. For use with plain water, the closet generally used for cement testing does very well, provided care is taken that it is so arranged as to maintain the air practically at 100 per cent. relative humidity. When using salt solutions, recourse must be had to the atomizing jet to insure the development of the salt fog.

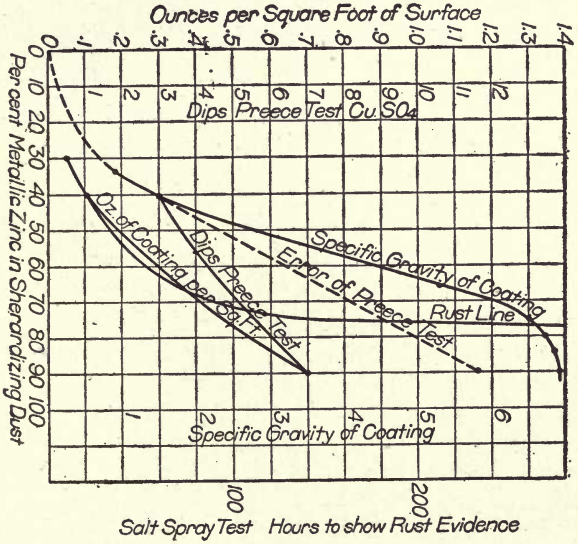

CHART III. RECORD OF COMPARATIVE TESTS

When exposed as described, articles have a very thin film of moisture over their surface, but there should be very few, if any, drops of sensible size on the objects. Obviously, the test is very searching, as all parts of the surface are exposed, and any pin holes or uncovered areas become evident. This gives one an opportunity

to learn something of the efficiency of any protecting process in taking care of edges, sharp corners, porous spots in the metal surface, etc. By noting the character of the general final breakdown, a very good idea of the evenness of the coating applied may be obtained.

The salt spray test, as it is called, has been used during the last four or five years, commercially, by the General Electric Company as a check upon the products of its process of Sherardizing. The coated articles are exposed to the salt fog, and are examined from time to time to note their service condition. When the coated material is iron in any of its several forms, red dust begins developing as soon as the coat breaks down. The appearance of red dust may be in small pin points which gradually extend, or it may appear generally over the surface of the article. When the coating is relatively thin and poor, rust may develop in from two to three hours to twenty-four hours, or longer. A better coat will last two or three days, but a well-applied coat of requisite thickness will last at least a week. If no rusting is developed in this time, it may safely be assumed that the life of the coating will be practically indefinite. These figures are based on experience with both Sherardizing and galvanizing.

This method of testing Sherardized articles is offered in replacement of the Preece test. Some reasons for this may be seen by referring to Chart III. As an example, we may take a sample with a deposit of .1377 oz. per square foot of surface, which has stood three dips in the Preece test, and a sample with .7 oz. per square foot of surface, or .5693 oz. more, which stood only 7 dips when it should have stood 11 or 12. The salt spray test is only an exaggeration of what may be expected at the seashore and differs only in degree, not in kind, from the normal conditions under which the article is intended to be used.

Hydrochloric Acid and Antimony Chloride Test for Sheets and Wire

Mr. J. A. Aupperle, metallurgical engineer, American Rolling Mill Company, Middletown, Ohio, offers a new method for testing the spelter coatings of sheets and wire in a paper read before the American Society for Testing Materials, Atlantic City, N, J., June 22, 1915.

It has been customary to express the weight of coating on wire

in pounds per mile, while on sheet products the results are usually expressed in ounces per square foot. Obviously, the coating on wire expressed in pounds per mile would have a different meaning for each gauge of wire. If the results are expressed in ounces per square foot of surface on both wire and sheets, there will be a better understanding as to the thickness of coating on the respective products. In stating the weight of coating on galvanized sheets it is customary to express the weight based on one surface only, that is, a sheet containing 2 oz. of coating per square foot really contains 1 oz. on each side of the sheet.

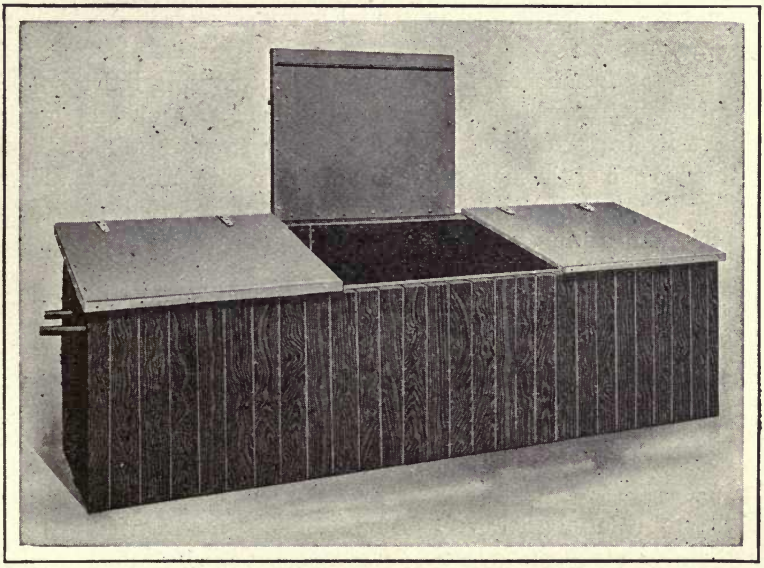

FIG. 133. SALT SPRAY TESTING BOX

It is proposed to express the weight of coating on wire in ounces per square foot, and also to use such lengths of wire that the number of grams of coating found will be equivalent to ounces per square foot, without calculation. These lengths must be such that the surface coated is equal to 5.079 sq. in. It is likewise proposed that the samples for determining the weight of coating on galvanized sheets shall be $2\frac{1}{4} \times 2\frac{1}{4}$ in. (area = 5.079 sq. in.). The number of grams of coating on a section of this size will also express the weight of coating in ounces per square foot without calculation.

The method for determining the weight of spelter coating consists of using a small amount of antimony chloride in hydrochloric acid (sp. gr. 1.20). Antimony chloride appears to hasten the solution of the coating, and after the coating has dissolved a thin film of antimony plates on the surface of the base metal and retards the solution of iron or steel. Experiments have shown that sheet steel 2¼ x 2¼ in. which loses 50 mg. in five minutes in cold hydrochloric acid (sp. gr. 1.20), will lose in that time only 1 mg. in the same acid containing 80 mg. of antimony per 105 c.c. of acid.

Determining Spelter Coating of Sheets

In the proposed method the metal is immersed in the acid only one minute, which is long enough to dissolve several grams of coating, yet the amount of iron or steel dissolved is negligible. The small amount of antimony that plates on the surface of the sample can easily be removed by scrubbing under running water. This method is one of the most rapid and accurate with which the writer is familiar, and a determination can be made in less time than is occupied in making the Preece test.

For determining the weight of coating on galvanized sheets cut several samples 2¼ x 2¼ in. from various parts of the sheet. These samples, about five in number, should be weighed together and immersed singly for 1 in. in 100 c.c. of hydrochloric acid (sp. gr. 1.20), to which has been added 5 c.c. of antimony chloride prepared by dissolving 20 g. of antimony trioxide in 1,000 c.c. of hydrochloric acid (sp. gr. 1.20). The same 100 c.c. of hydrochloric acid can be used for at least five samples. Five cubic centimeters of the antimony chloride, however, should be added for each sample on account of the antimony being removed from the solution by the iron.

The samples are washed and scrubbed under running water, dried with a towel, and laid in a warm place for a few seconds. The samples are again weighed together and the number of grams lost is divided by the number of samples taken. Each gram corresponds to 1 oz. of coating per square foot.

Determining Spelter Coating of Wire

A small section of the galvanized wire should be stripped in hydrochloric acid containing antimony chloride. The diameter of the black wire should then be carefully measured in order to

determine the length of wire, such that the number of grams of coating will represent the number of ounces per square foot of surface.

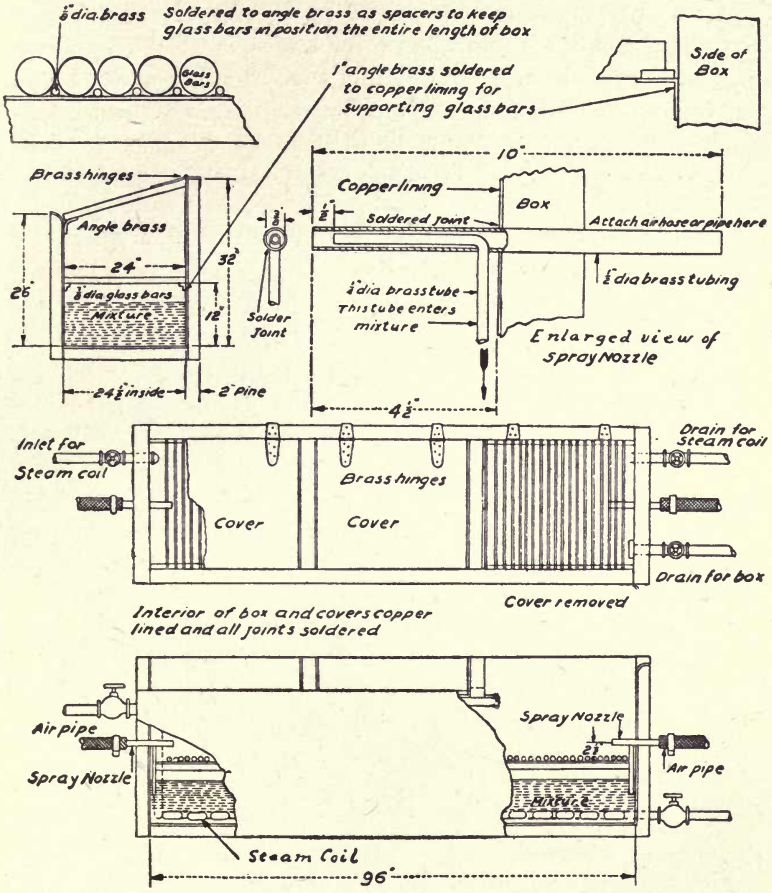

FIG. 134. DETAILS OF CONSTRUCTION OF SALT SPRAY TESTING BOX

The method of making the test is very similar to that outlined for galvanized sheets, except that the wire is first cleaned with carbon tetrachloride or gasoline, and after being carefully weighed is placed in a tall glass cylinder containing hydrochloric acid (sp. gr. 1.20), to which has been added from 2 to 3 c.c. of antimony-chloride solution of the same strength as used on galvanized sheets. The reason for using one-half the amount of antimony chloride

in the case of wire is on account of taking one-half the area. As previously stated, the coating on galvanized sheets is expressed in ounces per square foot, considering one side only, when in reality this amount of coating represents 2 sq. ft. of surface. After immersing the entire length of wire for 1 min. it will be found convenient to pour the acid solution into another tall cylinder in order to facilitate removing the wire. The wire is then scrubbed under running water, wiped, thoroughly dried in a warm place for a few seconds and again weighed. Each gram lost corresponds to 1 oz. of coating per square foot. For direct comparison with the weight of coating as expressed on galvanized sheets, this figure should be doubled.

CHAPTER XXXIII

Publicity Section

THIS chapter consists of paid advertisements prepared by the various manufacturers and supply dealers whose products are described. It has been included to give the readers of the book a Trade Directory to which they can refer when in need of equipment or supplies, as well as in disposing of their waste.

The advertisements given on the following pages have been classified as far as possible, and all have been indexed under the product and under the name of the manufacturer or dealer in the general index at the back of the book.

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If you do—or intend to do Tumbling you should have this practical treatise.

It represents ten years experience with Tumbling methods and Barrels—and contains some helpful pointers.

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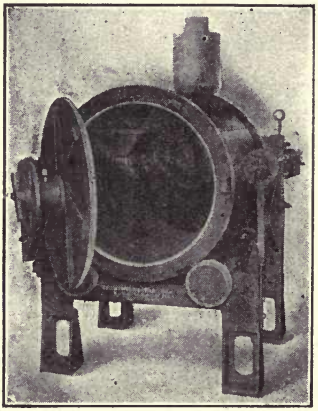
SAND-BLAST your work before galvanizing by any process. The wide-awake are doing it—why not you?



C. A. Dreisbach Patent 948270

The sand-blast eliminates to a great extent the water rolling barrel in preparing gray iron for tinning, and makes the tinning of castings that can not be prepared by water rolling a comparatively easy matter. It is of great value in the preparation of old work for re-galvanizing. It eliminates the objections to acid and is a great saving in time over the pickling process.

A brighter finish is obtained on sand-blasted work than on pickled work. It effects a great saving on parts to be machined, as it gets into corners where acid fails, and will reduce maintenance cost of cutting tools and equipment. The saving in this direction, including labor, is from 20 to 25 per cent.

Much more can be said in favor of the sand-blast than space permits. Send for catalogue and further information.

THE NEW HAVEN SAND-BLAST COMPANY
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for the further operation of Galvanizing, Tinning, etc., can often be best accomplished by the use of Tumbling Barrels.

BAIRD HORIZONTAL GRINDING BARREL—is furnished either in the exhaust or non-exhaust type. Send for Bulletin No. 302.

BAIRD OBLIQUE TILTING TUMBLERS—are made in various sizes and having barrels of different materials. Send for Bulletin No. 300.

These barrels are also used for electro-galvanizing.

BAIRD BALL BURNISHING MACHINE—is of a particularly practical construction. Send for Bulletin No. 303.

THE BAIRD MACHINE COMPANY
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R. CRUICKSHANK, Birmingham
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Silver Metal

Is a Superior FLUX ALLOY For Improved Galvanizing at Decreased Cost

You don't change your process. You simply add from one to two pounds of Silver Metal to each ton of spelter in your bath. When amalgamation is complete, your product is bright with a sparkle that endures. Silver Metal quickens and liquifies the bath, compelling a thin, uniform coating. Usual saving in spelter is from 10 to 15 per cent. Blisters and defects are reduced. You can stamp and bend with lessened danger of cracking or peeling. Density is increased, thereby preventing, to a greater extent, the penetration of the humid air through to the underlying metal.

Silver Metal permits efficient galvanizing at a moderate heat, from 800 to 850 degrees Fahr., reducing the zinc ashes and prolonging the life of the pots. High heat promotes dross spot deposits. and the rapid burning of the sal-ammoniac makes excessive skimmings. Reckon the cost of your discards. Spots and blemishes are expensive.

Like a Flash SILVER METAL

promotes galvanic action. The more instantly action is set up between metals on exposure to humidity of air, the more efficient and lasting is the result.

Malleable Iron Fittings Co., Branford, Conn., says:

"We are pleased to be able to state that we consider Silver Metal most excellent as a fluxing metal in the galvanizing bath, adding luster to the work and promoting fluidity in the bath. In addition, we have found that galvanizing retains its color much better when the flux is used in the right quantity than would otherwise be the case. The above conclusions are the result of several years' use of the flux."

American Can Company, Toledo, Ohio, says:

"We wish to state that Silver Metal has given us perfect satisfaction in every respect. We find by using this galvanizing flux that we get much better results than without. The goods coming from the galvanizing kettle have a bright or brilliant finish which we cannot obtain without using the flux. Furthermore, it has a tendency to make the spelter more liquid, and we find quite an economy in using it."

American Wringer Co., Woonsocket, R. I., says;

"We have been using your galvanizing flux or Silver Metal for a long time, and wish to state that it so far has given us good satisfaction. We find by using your galvanizing flux that we get better results. Our stock is brighter and has a smoother finish than we ever had before using it. It keeps the spelter in better condition and we find that it not only gives us better work but it is economy to use it, and we would not be without it."

Wm. B. Scaife & Sons Co., Oakmont, Pa., says:

"We are very much pleased with the results that we obtain from Silver Metal, and we find that it adds greatly to the appearance of our galvanized Range Boilers and makes the metal run more smoothly."

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If you do electro galvanizing, we have an interesting proposition to offer. *By using Silver Star Anodes* in place of ordinary Spelter Anodes, you can increase your efficiency 40 to 50%, by doing your work *faster*, *better* and *materially cutting your cost.*

Silver Star Anodes will also provide a better, more lasting and uniformly brighter coating, free from spots, than any other Anode on the market.

Full details furnished upon application.

SILVER STAR SPELTER

Guaranteed 99.75%

Suitable for all high grade and extraordinary requirements.

Average Analysis from Stock:

Zinc,	99.900 per cent.	Lead,	.065 per cent.
Iron,	.020 per cent.	Cadmium,	.010 per cent.

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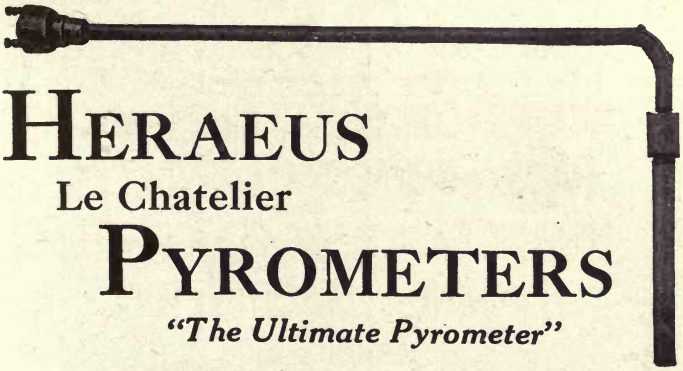

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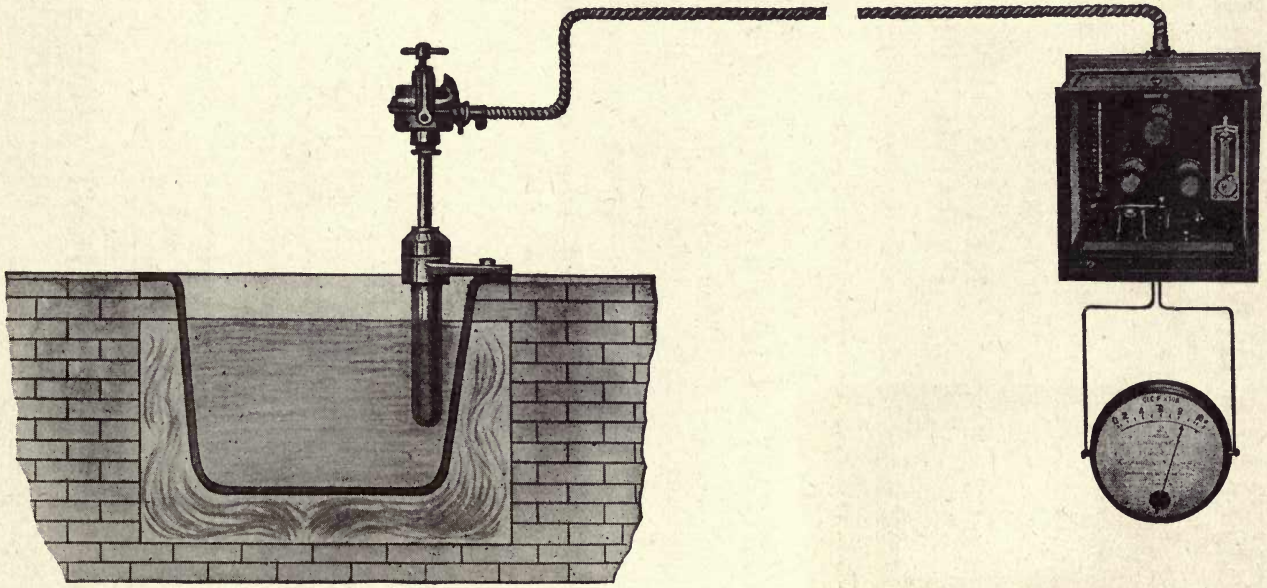

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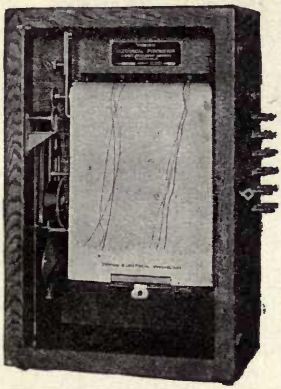

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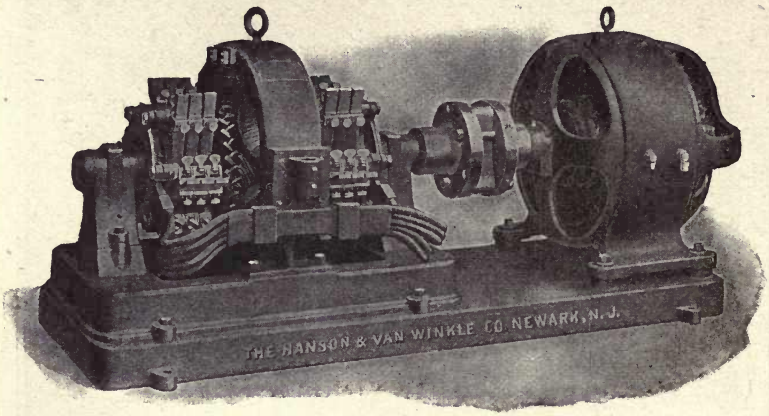

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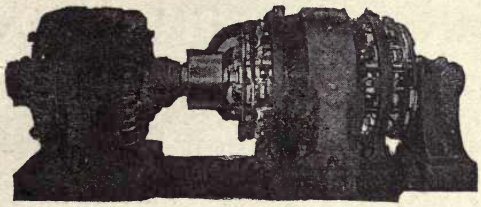

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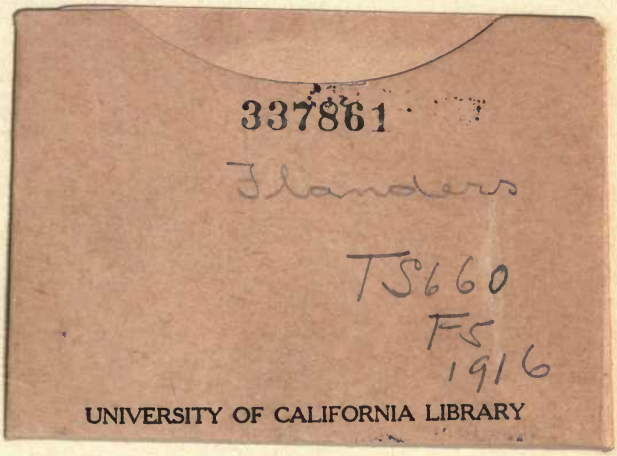

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